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INSECT AND MITE PESTS OF OHIO APPLES

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AGRICULTURAL
EXPERIMENT STATION
WOOSTER, OHIO

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Important Note on Illustrations

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INSECT and MITE PESTS of OHIO APPLES

C. R. CUTRIGHT*

INTRODUCTION

Some of the pests that attack Ohio apples are present in damaging numbers every year. Others appear from time to time in a more or less cyclic pattern but must always be considered as possible objects for control when the spray schedule is planned. Still others may be present in serious numbers for a year or more, then decline to a point where it is not necessary to consider them as pests. However, once an insect or mite has caused damage there is always a possibility of its return and therefore, it can not be completely forgotten.

When all pests of the various classes are listed their total number is surprisingly large. So large in fact that space prevents the consideration and discussion of all of them in a publication of this type. Therefore in preparation of this bulletin only those insects and mites with known capacity for damage under Ohio conditions are included. The most serious of these will be discussed more fully than those of a minor nature.

For purposes of reference the different pests of apple will be divided into four groups, namely: (1) insects attacking the fruits, (2) insects and mites attacking buds and foliage, (3) insects attacking twigs and small branches, and (4) insects attacking the trunk, larger branches and roots. Species which attack both fruit and foliage, or buds and branches are placed in the group where they cause the most damage.

Since control measures are subject almost annually to changes, this bulletin will not deal with the methods or the economics of insect and mite suppression. The purpose of this publication is to acquaint the apple grower and other interested persons with the pests themselves, and the types of damage that each one produces. Successful control demands knowledge of the identity of the insect and its habits, as well as the nature, type and amount of damage that is occurring. It is hoped that this bulletin will aid in supplying this information.

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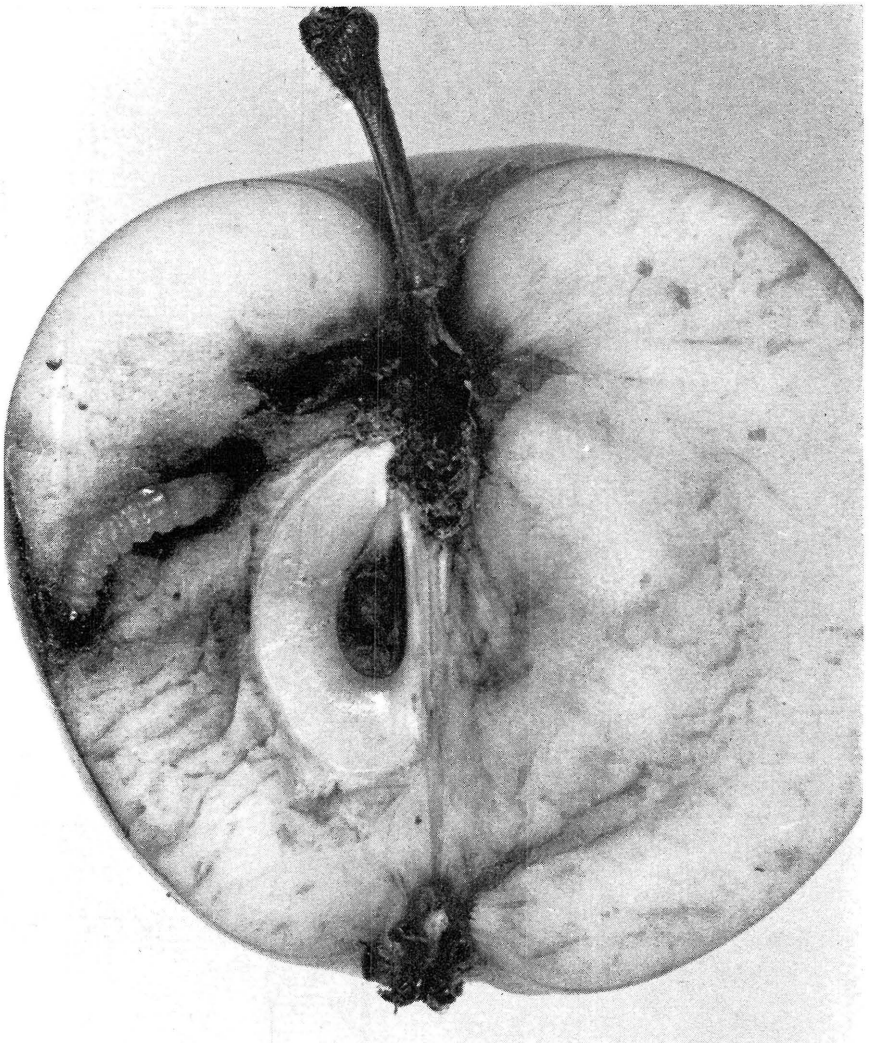


Fig. 1.—Codling moth larva in apple. (Courtesy Dept. of Public Relations, Ontario Agricultural College, Guelph, Ontario).

INSECTS ATTACKING THE FRUIT

THE CODLING MOTH CARPOCAPSA POMONELLA (LINNAEUS)

The codling moth is an introduced insect whose original home was Asia Minor. It was carried into Europe by invading migrants and from this point has been disseminated to all apple growing areas of the world. It was brought to America by the colonists and has been one of the principal apple pests for more than two hundred years. It became serious in Ohio shortly after the Civil War and continued so until about 1900 when use of the arsenicals became wide spread. From this time to the early 1930's commercial orchardists generally controlled it effectively, although some losses began to occur about 1925. These control failures were largely due to the development of resistance on the part of the codling moth to lead arsenate. Increasing losses were experienced until 1946 when DDT came into use. The insect was then well controlled for the next 10 years. At this time DDT began to lose its effectiveness, but with new insecticides such as Sevin and Guthion injury by this pest was very light from 1959 to 1961. In certain per-

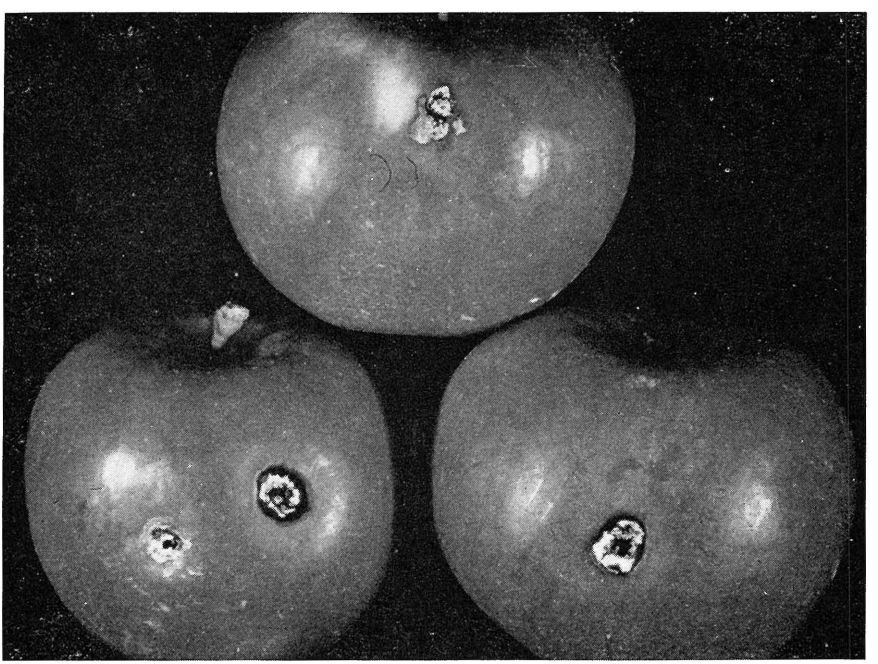


Fig. 2.—Codling moth injury to apple. Sideworm entrances.

iods it was undoubtedly the "Number 1" insect pest of apples, but at other times it was relatively unimportant. Even with the new effective spray chemicals of today, the codling moth must still be considered an ever present threat.

In addition to apple, this insect also attacks pears, crab apples, quinces and occasionally other fruits. The English walnut is another favorite host. Injury is caused by the larvae which bore into the fruit leaving an unsightly entrance hole as well as tunnels through the flesh

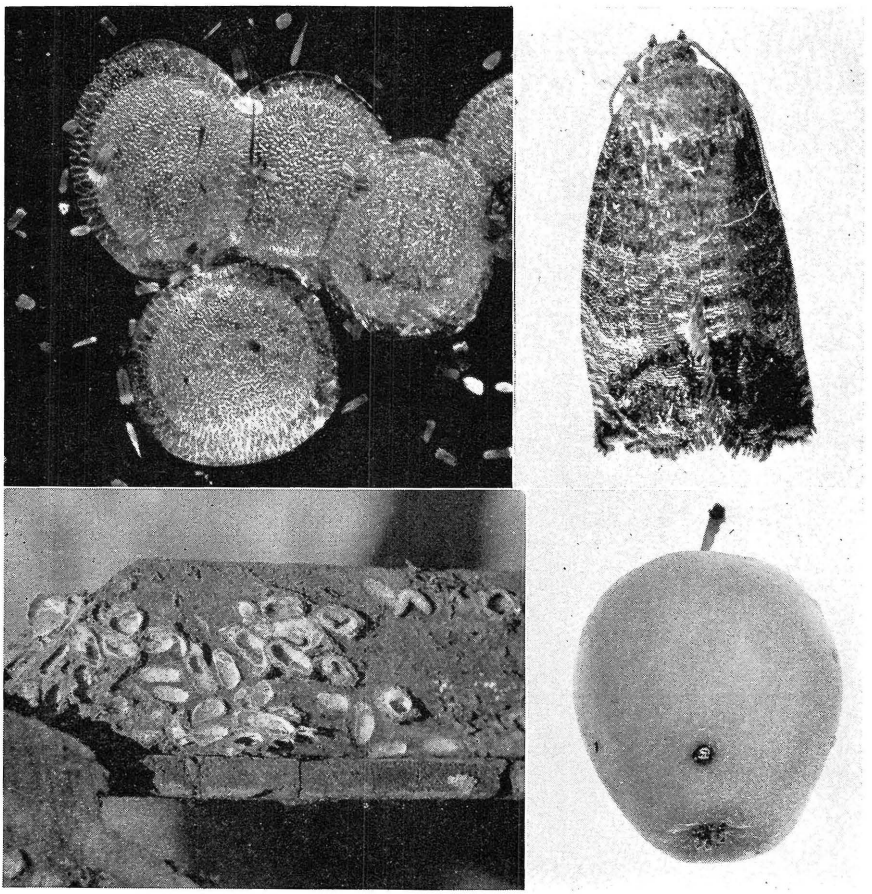


Plate I. Fig.—A. Eggs of the codling moth (greatly enlarged).
Fig.—B. Adult Codling moth (enlarged x 2).
Fig.—C. Codling moth cocoons and larvae on slat of apple crate.
Fig.—D. Codling moth "sting". (A "sting" is an injury produced by a young larva that dies in attempting to enter the apple).

and core. (Fig. 1) "Stings" which occur when the larva breaks the skin and feeds briefly before dying are also a reason for the down grading of fruit. (Plate I, Fig. D)

Life History: The codling moth overwinters as mature larvae in tightly-constructed silken cocoons located principally under loose bark on the tree trunk and larger limbs. (Plate I, Fig. C) Coccoons may also be found in other places in the orchard such as piles of wood, brush, posts and occasionally in coarse mulch such as weed stalks and corn cobs. In addition larvae overwinter in stored baskets or crates that have contained cull fruit and in the walls of packing sheds and other buildings adjacent to the orchard.

The overwintering larvae start to transfer to pupae inside the cocoon about the time that the first blossoms show color. The bulk of pupation usually occurs during bloom but some larvae may not transform until a month later. Prior to pupation the larvae cuts a circular opening in one end of the cocoon and it is through this aperture that the pupae thrusts its way just before the emergence of the moth.

In size the moth will average a little less than one-half inch in body length and about three-fourths inch across the expanded wings. The first impression of the general color is gray but it is actually gray-brown, criss-crossed with lighter gray lines. Near the tips of the forewings are bronzed areas. (Plate I, Fig. B) The first moth of the season usually appears as the last petals fall from the apple blossoms. Peak emergence may occur within four or five days after the first moth emerges or weather conditions, such as low temperature may delay it as much as 10 or 12 days. The last moths of the season may not appear until six or seven weeks after petal fall. Moths emerge usually during the morning hours and within two or three days begin laying eggs if the evening temperatures are favorable. This will occur only when temperatures are above 62° Fahrenheit. Few eggs are laid at this low point but when temperatures approach 70° F egg deposition is greatly increased and above this point an even greater number will be laid. The egg is a very small, flattened, almost transparent disc. (Plate I, Fig. A) They are laid on the fruit or on nearby leaves. Eggs hatch in 8 to 14 days depending on the prevailing temperatures. The newly hatched larvae is white with a black head and is large enough to be seen with the naked eye. Those hatching on leaves wander about seeking the fruits which many of them fail to find. When on the fruit, larvae may wander about seeking a rough area, such as the calyx or a scab spot which aids them in making an entrance. The silken threads against which they brace themselves, while digging in, are more securely anchored to rough areas. If successful in entering, they feed inside the apple for about

three weeks (Fig. 1) after which they leave it and seek a cocooning site on the trunk or larger branches of the tree. If the apple has fallen to the ground the emerging larva will travel in circles until it comes to the tree trunk or other solid object where it will find cocooning quarters. The mature larva is white, usually tinged with pink, its head is brown and it will measure approximately one-half inch in length.

The time spent in the cocoon depends on temperature and rainfall but usually lasts from 14 to 21 days. However, many larvae do not transform to pupae during this time but continue as larvae until the next spring. Those that will emerge as moths of the second brood pupate in the cocoon as already described and start emerging as early as July 6 or as late as July 24 according to the season. Average peak emergence at Wooster occurs during the first three days of August after which it declines, usually ending during the first few days of September. Second brood moths will lay eggs over a period of about two months. Mature larvae of the second brood start leaving the apples in mid-August and continue until apples are removed from the orchard or until very cold weather arrives. These larvae together with those of the first brood that did not pupate, will overwinter and start the cycle again next spring.

The foregoing account of the life history of the codling moth is based on continuous studies and observations that have been made at Wooster from 1926 to 1962 inclusive. In all seasons the influence of climatic conditions on the activities of the codling moth have been most definite. Temperature is the most important of the climatic factors, but humidity, rainfall, and winds are also important. If high temperatures prevail during the season, adult codling moths will emerge earlier in the spring and deposit a greater number of eggs. These will hatch earlier in the season and in greater numbers and in turn more of these larvae will succeed in finding and entering the fruit. In the fruit they feed more voraciously than in cool weather and become mature at an earlier date. They leave the fruit, succeed in finding cocooning quarters, and the moths again emerge earlier. This acceleration of first-brood development means that second brood attack comes earlier, with larger numbers of moths to lay eggs and if high temperatures continue, all activities proceed at the same rapid pace. On the other hand if the season is cool all the life processes of the insect are slower and less vigorous, thereby resulting in greater ease of control. However, in seasons with alternating hot and cool periods the codling moth takes advantage of every warm period. Even one warm fortnight may be enough to cause trouble for the grower.

Rainfall and moisture are needed to hasten the development of pupae and the emergence of moths. Low humidities on the other hand seem to aid in the establishment of the larvae entering the fruit. Heavy winds will cause the moths to cling to protected hiding places while light breezes will aid in their flight and distribution.

History of Control: During past years all sorts of efforts have been made to control the codling moth. Most of them have fallen in the following categories: (1) mechanical, (2) biological, (3) chemical or (4) combinations of these. The first recommended controls were of a mechanical nature, such as picking up and removing the infested fruit and placing around the trees bands under which the worms were trapped. The first bands were hay twists which were removed and burned at intervals. Later cloth and paper or corrugated paper bands were employed. The so-called poison bands that were used from 1935-45 were made by saturating strips of corrugated paper with chemicals such as Beta-Napthol. These chemicals were toxic to the larvae that used the interspaces for cocooning and high percentages of them were killed. Banding at its best, however, has only been a minor aid in control and in competition with effective spray chemicals the practice has been abandoned.

Biological controls have been investigated at length. These included the rearing of different parasites of the codling moth, and their release in the orchards where it was hoped that they would reduce the numbers of the pest to an insignificant level. In several instances orchards have been sprayed with chemicals non-toxic to the various parasites and predators and all other methods to protect the beneficial species were used in hopes that nature would provide a control. In certain areas measures such as these have been reported as partly successful. In other cases such methods have failed. Bacteria and a species of nematode have been sprayed on trees to test the possibility of their use.

Since the introduction of the first arsenicals, chemicals have given the best results in the control of the codling moth. The various successes and failures with the different spray chemicals have already been noted. At present the two most effective chemicals for use against the codling moth in Ohio are Sevin and Guthion. It is of interest to note, however, that in some Ohio orchards lead arsenate can still be effectively used. DDT has by no means lost its effectiveness in some areas and may still be relied upon.

For the latest spray recommendations and schedule arrangements the reader is referred to the current spray charts and bulletins.

THE PLUM CURCULIO CONOTRACHELUS NENUPHAR **(HERBST)**

As the name implies plums are seriously attacked, as are peaches, and cherries. However, of all the curculios and weevils that attack apples and pears this is the most damaging species. It is found in every orchard and even if injury is light any let down in the control program will permit much damage. Apples on unsprayed trees may be 100 percent attacked.

Life History: The adult curculio which overwinters in debris on the ground, in fence rows, and woodland, is a small dark brownish snout beetle about one-fourth inch long. (Fig. 3) There are four prominent, black tubercles, two on each wing cover. A few individuals will come out of hibernation about the time that the first apple blossoms show pink. Where an orchard is heavily infested, this early emergence is the reason for spraying against the curculio at the time of the last pre-blossom, "Pink" spray. Most adult curculios, however, emerge during the blossoming and "petal fall" period. Stragglers will continue to appear for three to four weeks after blossoming has ended. Early emerging beetles feed on buds, foliage, and later on the young fruits. Apples may be fed upon and eggs deposited in them even be-

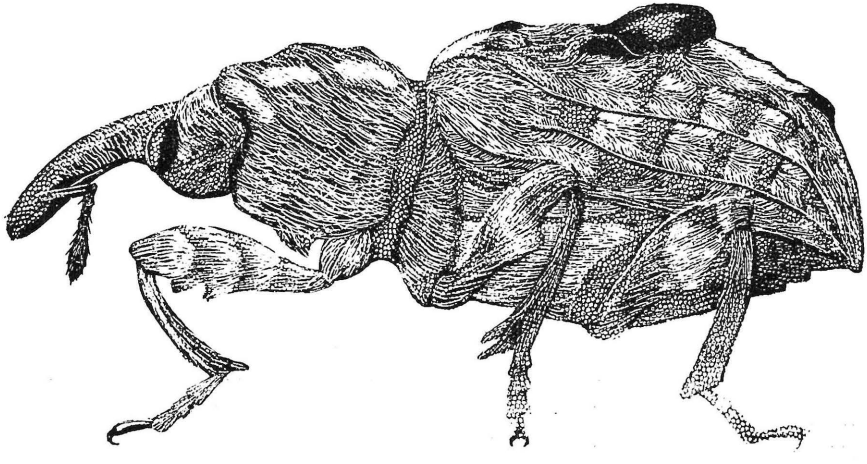


Fig. 3.—Adult plum curculio.

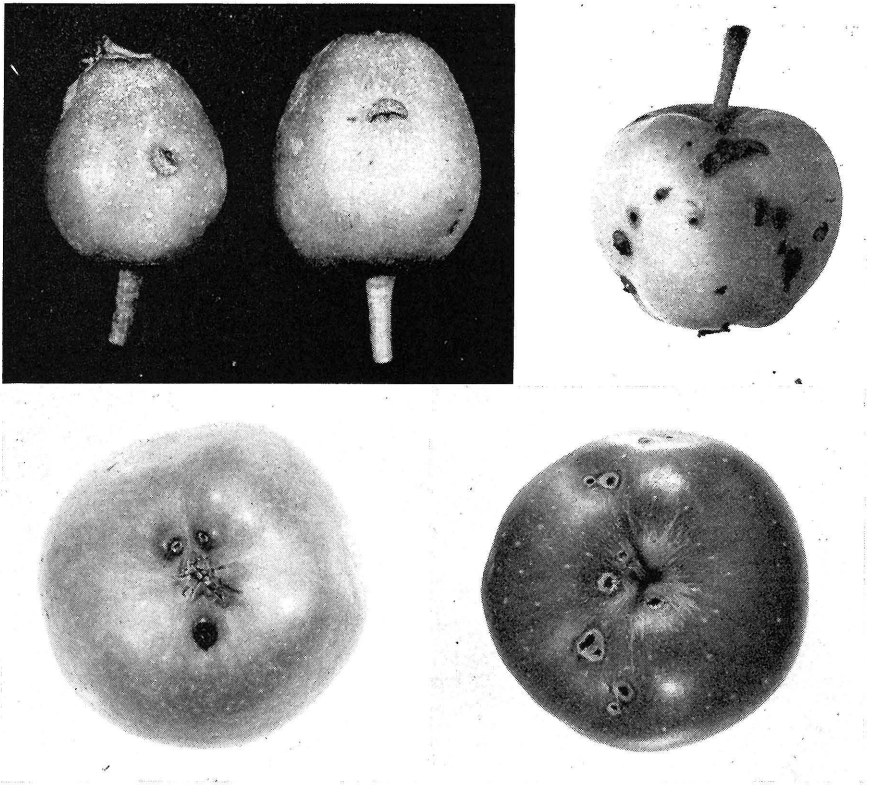


Plate II.—A. Plum curculio egg laying scars on young apples.
B. Immature apple deformed by plum curculio egg laying and feeding.
C. Plum curculio feeding punctures around calyx of apple.
D. Plum curculio feeding punctures around stem end of apple.

fore they are one-fourth inch in diameter. (Plate II, Fig. A) In egg laying, a cavity is made in the fruit and an egg placed in it, after which a crescent-shaped cut is made adjacent to the egg pocket. This relieves pressure of the growing fruit on the egg. However, very few if any of the young larvae survive to maturity if the apple continues to grow on the tree. The egg or the larva is crushed by the firm growing tissues of the fruit. On the other hand if the apple drops or is picked from the tree while the larva is still alive it will complete its growth. Because of this fact curculio scarred apples removed in thinning should not be dropped to the ground but should be removed from the orchard

and destroyed. Several years ago at Wooster more than 600 curculio marked fruits were picked from the ground following thinning. From these some 300 larvae were reared. If the apples had remained on the ground many of these larvae would have emerged later as adult curculios and control would have been much more difficult.

The eggs hatch in from five to seven days and in suitable fruits the larvae feed for about three weeks after which they leave the apples and enter the soil for pupation. About a month is usually spent in the soil before the adult emerges. As there is only one generation each year in Ohio these adults do not mate or lay eggs. Their activities are limited to feeding on the fruits resulting in circular, black edged pits which are noted often during late summer and early fall. (Plate II, Figs. C, D) Some adults enter hibernation in September while others delay until October or early November.

The early feeding and egg-laying punctures, coupled with some feeding by the young larvae in the fruits, cause marked scarring and malformation of the fruit. (Plate II, Figs. A, B)

In nature both the larvae and the adults of the plum curculio may be attacked by a fungus disease. Parasites attack eggs and larvae and birds and other predators feed upon them. Hard dry soil may prevent the emergence of the adults in late summer.

The development of control measures against the plum curculio gives a good example of the evolution of controls as they apply to insects in general. First there were controls based on superstition and hearsay, such as putting wood ashes about the base of the tree or painting the trunk with diluted lye water. Jarring the beetles from the tree onto a white cloth and collecting them by hand was a common practice during the late nineteenth century. Then came spraying with Paris green, London purple, and with lead arsenate which was the standard control for many years and which is still widely used. Parathion and other organophosphates can be used but at present (1962) dieldrin is the most effective of the different chemicals.

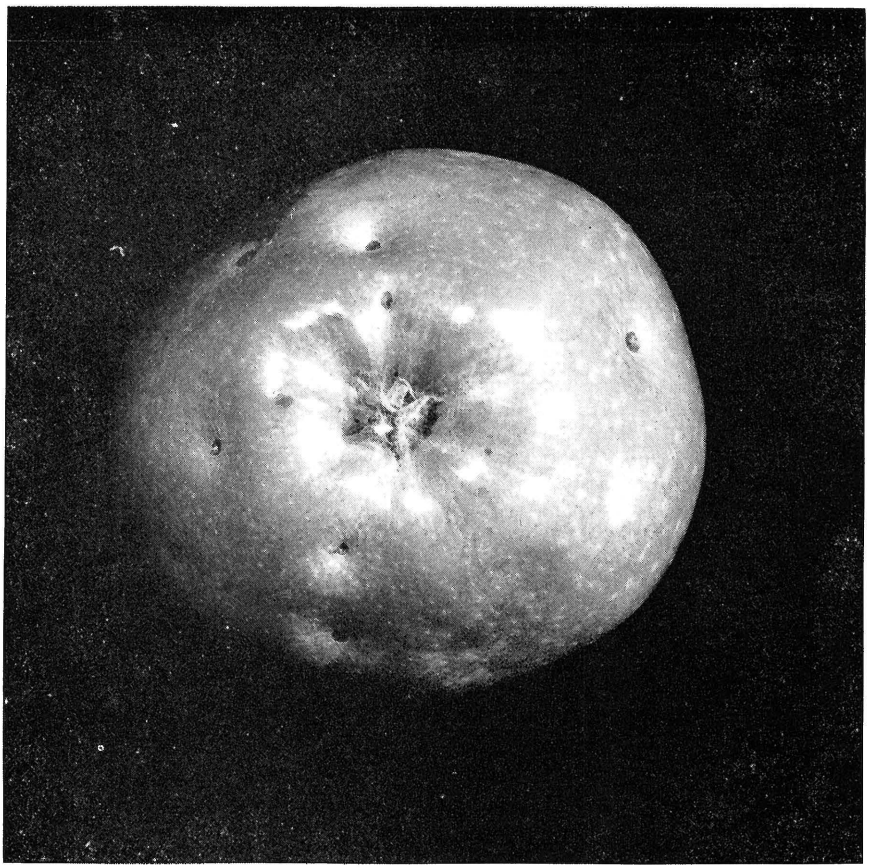


Fig. 4.—Injury by apple curculio to fruit.

THE APPLE CURCULIO TACHYPTERELLUS QUADRIGIBBUS **(SAY)**

This native insect is widely distributed in the U. S. east of the Mississippi River. The adults resemble somewhat those of the plum curculio but are slightly smaller with a much longer snout. The egg puncture also resembles that of the plum curculio but the scar tissue that develops may form a very prominent, russetted hump on the surface of the apple. (Fig. 4). The larvae are able to live in growing fruit and many feed in and around the core. In general the life history is much the same as that of the plum curculio. Instances of severe injury by this species in Ohio have been noted but it is usually a pest of minor importance.

THE APPLE MAGGOT RHAGOLETIS POMONELLA **(WALSH)**

For many years the home apple grower with a few trees has had difficulty with the apple maggot or railroad worm, a native of the northeastern United States and eastern Canada.

The maggot's original food was wild haws and crab apples. However, more than a hundred years ago it began to infest apples in New England and since that time has migrated into all major apple-growing sections of the eastern United States. The maggot also infests pears, plums, and blueberries. Surfaces of severely injured fruits are dimpled and gnarled. (Fig. 5) This damage is caused by punctures in the skin during egg laying and tunnels in the fruit caused by feeding of the larvae or maggots which have hatched from the eggs. Characteristic apple maggot injury is shown in the photographs (Figs. 5-6). Lightly infested fruits, however, may appear quite normal.

The parent insect is a dark-colored fly of the same general shape and size as the common house fly. (Fig. 7) However, the wings of the apple maggot fly carry a distinct black pattern. The abdomen of the female has four fairly distinct transverse white stripes while the male has three. The flies are somewhat sluggish and can easily be captured in a net or wide-mouthed bottle. In July and August, on heavily infested trees, they are readily seen on leaves and fruits of the lower branches. They prefer shade and are most easily seen from the inside of the tree.

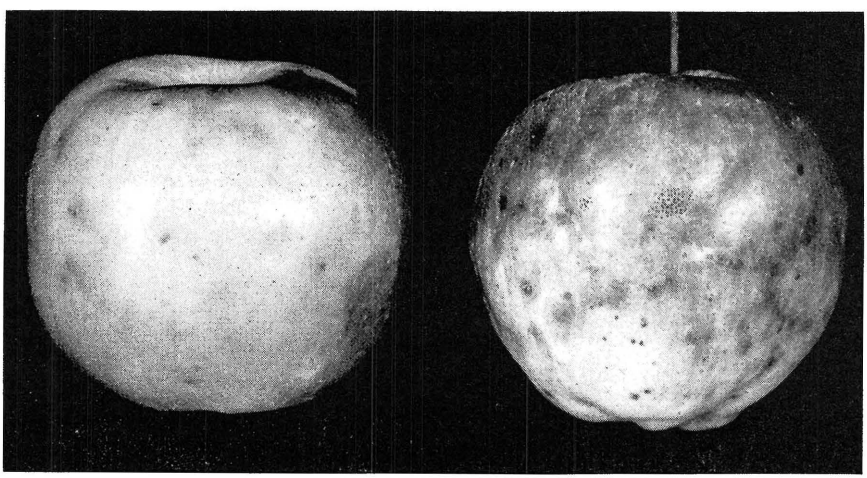
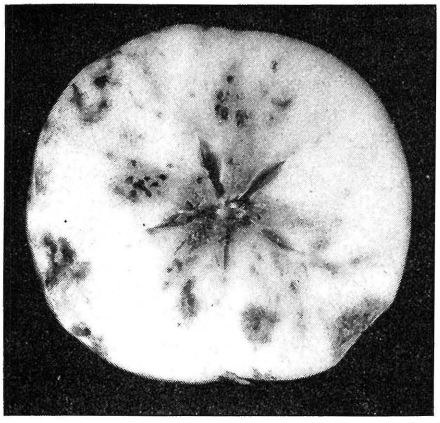
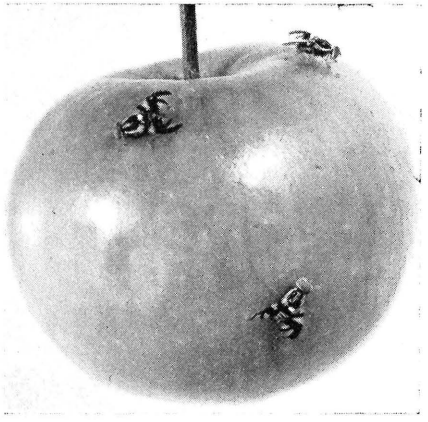


Fig. 5.—Apple maggot injury. Apple on left shows a few egg punctures and relatively little external injury. Apple on right shows many egg punctures and severe injury.





Figs. 6. and 7.—Cross-section of apple showing injury by apple maggot larvae, left. Apple maggot flies on apple, right. (Courtesy Connecticut Agricultural Experiment Station).

In Ohio the flies start to emerge from the soil in late June or early July, according to the season. Emergence continues during July and August, and second-brood flies appear in late August and in September. Thus, there may be flies in the orchard continuously from late June to October. However, they are present in greatest numbers from late July to late August.

When flies emerge, they usually spend from 10 to 14 days flying about from tree to tree. At the end of this period they always come to host trees for egg laying.

The small, yellowish-white eggs are laid just under the skin of the fruit. They hatch in a few days and the small maggots immediately start to burrow through the fruit. If the fruit is near maturity, growth is rapid and the larvae mature and leave the fruit in 8 to 12 days. However, if the eggs are laid in immature apples or winter varieties, growth is much slower and many maggots die due to hardness of the fruit. If apples fall to the ground, the number of surviving maggots is larger.

One or two egg punctures in a fruit are inconspicuous, hence, a good-looking apple may be found with the inside ruined. However, an apple becomes deformed when it carries 20 to 30 egg punctures. The maggots burrow at random through the fruit, usually avoiding the core. Burrows are frequently seen just beneath the skin.

Maggots leave the fruit by a small opening and at once enter the soil. Here they are usually found near the surface, but at times they may go to a depth of five or six inches. They transform at once to puparia within which the true pupa is shortly formed. Some of the first brood pupae transform to adults and emerge, as previously noted, in late August and in September. However, the majority remain in the soil over winter and emerge the following summer. There are also a few which stay in the soil for two winters before appearing as adult flies.

Due to the dispersing habit of the flies, the person owning one or two trees is faced with a difficult control problem if his trees are located near other trees that are untreated. In commercial orchards the problem is much less difficult. Under conditions of severe infestation it is obvious that a joint effort toward control by all owners of fruit trees in a neighborhood is highly desirable.

Spraying with effective insecticides where infestations are severe is the best method of control. Soil treatments to kill the larvae are also recommended. Consult the latest spray programs for best methods and materials to use.

THE RED-BANDED LEAF ROLLER ARGYROTAENIA VELUTINANA **(WALKER)**

This is a native North American insect that has been known for many years. However, it was a very minor pest of fruit in Ohio until 1947 when, following the widespread use of DDT as an orchard spray, it became quite destructive. Apples are the principal object of its attack, but all other fruits including grapes and brambles may be seriously injured. In addition, it will live on numerous weeds, flowers, vegetables, shrubs, and trees.

The larva, which is the injurious stage of this pest, is yellowish-green in color with two lighter colored strips, one on each side of the body. The head is never black but it about the same color shade as the body. When mature, the body color may not be as bright as that of the younger larvae. Just prior to pupation, larvae will measure from one-half to three-fourths of an inch in length, and the body is somewhat oval or flattened rather than cylindrical. Larvae are very active when disturbed.

The pupae are similar to those of many other small moths. They are usually less than one-half inch in length, brown, and are found in curled or rolled leaves.

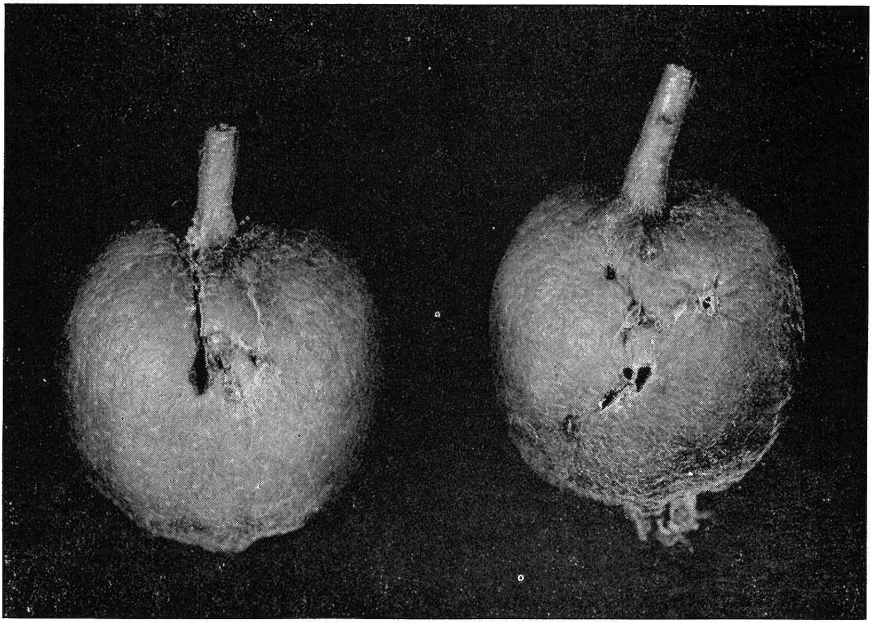


Fig. 8.—Injury by red-banded leaf roller larva to young apples.

The moth is small with a wing spread that seldom exceeds three-fourths of an inch. The name, "red-banded," comes from a relatively broad reddish-brown band that runs across the wings. The moths are rather weak and erratic in flight.

Life History: The insect passes the winter as pupae in a silken cocoon inside of curled leaves on which they have fed and which have fallen to the ground. The first moths of the spring brood emerge about the time that apple buds are opening in April. Egg laying starts before many leaves are out and continues until after bloom. The eggs are small, disc-like, and pale yellow in color. They are laid in masses usually containing from 10 to 100 eggs and are attached to twigs or small branches. The egg mass has a grayish-yellow color. Hatching starts while the trees are in bloom and is not completed until after the time of the first cover spray. The larvae feed over a period of four to five weeks, then pupate inside the curled leaves where they have been feeding. Larvae of the first generation do not generally attack fruits. Moths of the first generation emerge in Ohio during the second half of June and in July.

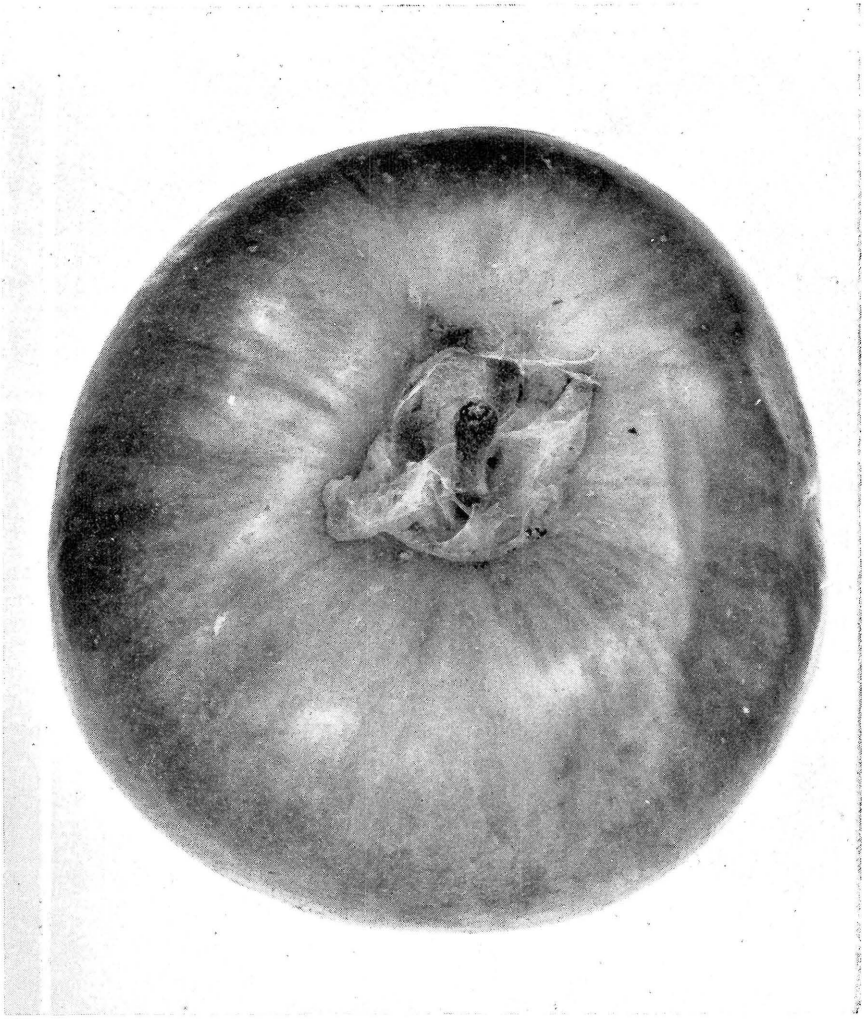


Fig. 9.—Injury by red-banded leaf roller larva around stem end of apple. Note the web covering the injury.

The development of the second generation is much the same as for the first except that it requires less time because of the higher temperatures which prevail at this season. Some eggs may be laid in late June but most are deposited in July. Larvae will be feeding from July to mid-August. More of these larvae will attack the fruit than

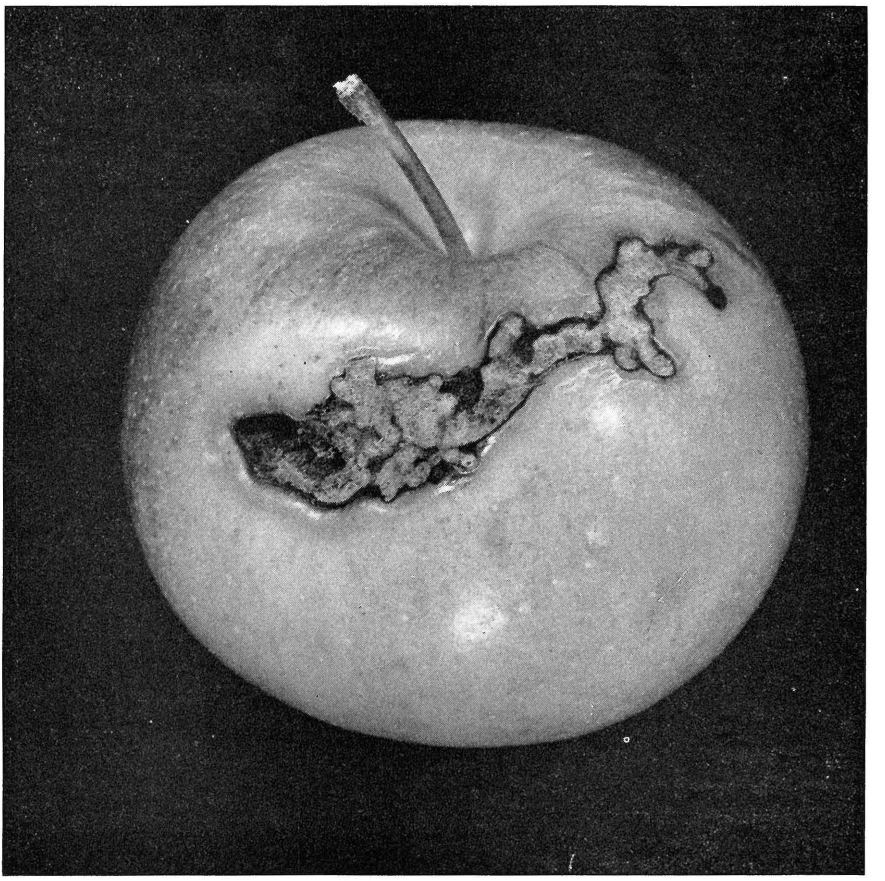


Fig. 10.—Typical injury to apple caused by feeding of the red-banded leaf roller larva.

was the case with those of the first brood. In August, moths of the second generation appear and eggs may be laid from late in the month to late September. The third-generation larvae that hatch from these eggs are the ones that the grower finds attacking his fruit during the harvest season. More than half of these larvae will feed on the fruit. (Figs. 9 and 10) Most of the third brood larvae mature and pupate before winter, but some which hatch late may not be able to complete their growth.

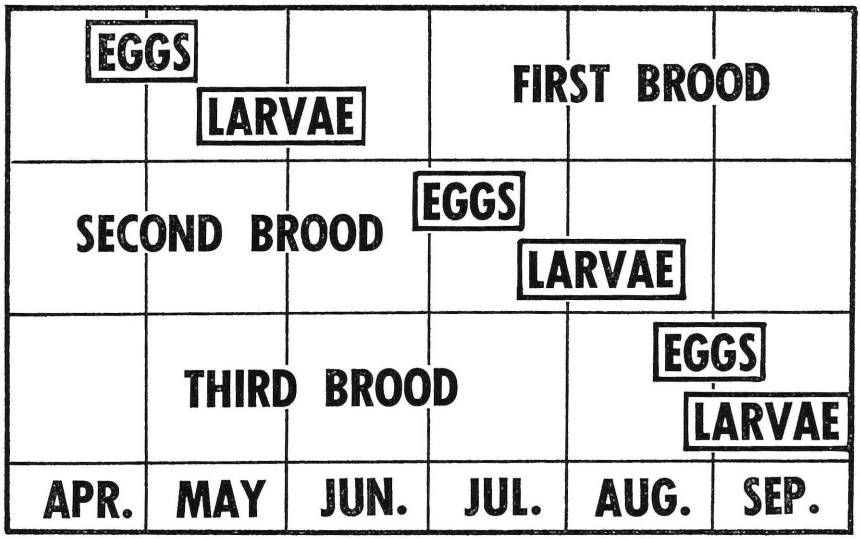


Fig. 11.—Diagrammatic life history chart of the red-banded leaf roller as it occurs in northern Ohio. Note that three broods occur annually with the hatches occurring from April through September.

A summary of the life history in diagramatic form is presented in Figure 11.

It must be recognized that the life history of the red-banded leaf roller will vary greatly from year to year according to temperatures and other factors. For example, in 1960 and 1961 the low temperatures of May and the summer months greatly delayed the development of the second and third larval generations.

Damage is done by the larvae feeding on the surface of the fruit. The skin of the fruit together with some flesh is eaten from irregular areas of different sizes. (Fig. 10) Deep holes in the fruit are very rare. The area where feeding occurs is always covered by a leaf, or another fruit, or by a silken web. (Fig. 9) Fruits that develop in clusters are particularly subject to attack. Young larvae, particularly in early season, feed along the midrib of the leaves, and are also covered by webbing. Later the leaves may be rolled and tied together by silk. They also attack the tips of water sprouts and succulent twigs.

THE FRUIT-TREE LEAF ROLLER ARCHIPS ARGYROSPILUS (WALKER)

This is also a native species that is found in all principal apple growing sections of the United States and Canada. The eggs, which are the overwintering stage, are laid in an oval mass on the twigs and branches. This mass is gray in color and usually contains 100 to 150 eggs. These hatch as buds begin to open. The larvae then feed on buds and leaves, and later on the fruits. Injury is somewhat similar to that caused by the red-banded species. The larvae complete their growth in June, pupate, and moths emerge during July. These deposit the eggs that overwinter. Thus, there is only one generation a year. Recently this pest has been of little importance in Ohio orchards.

THE ROSY APPLE APHID ANURAPHIS ROSEA BAKER

Ths insect causes serious injury to apple when it is abundant and is potentially our most dangerous aphid species. In New York and other, states, there are cases in which 50 percent of the apple crop has been lost through attack by this aphid. In Ohio it is not so abundant, hence instances of such severe damage are quite rare. In some orchards, however, it is sufficiently abundant in certain years to cause the growers considerable concern. The habit of appearing in great numbers one year and being almost entirely absent for one, two, or more years following is common to many aphids and with this species this phenomenon seems to be accentuated. The uncertainty of the presence or absence of this aphid from year to year is a matter of concern to all apple growers when planning control programs for the year.

Injury: Feeding by the rosy apple aphid on foliage causes the leaf to twist and curl around the aphid and its progeny, thus protecting them from sprays and rain. (Plate III, Figs. B and D) When young fruits are attacked, dwarfing and gnarling follow and normal thinning of the fruit cluster is prevented. (Plate III, Fig. C) These small distorted fruits are almost worthless.

Life History: The overwintering eggs are deposited under bark scales and around roughened areas on branches usually somewhat larger than those on which the eggs of the apple grain aphid are found. The females of the rosy apple aphid are far less numerous in autumn than those of other aphid species, hence the eggs are far less in number. In Ohio it is doubtful if these eggs account for more than one percent of the total present on apple. The majority of hatching occurs about a week after that of the apple grain aphid and due to this fact the young are smaller than other aphids that are present. They are dark purple

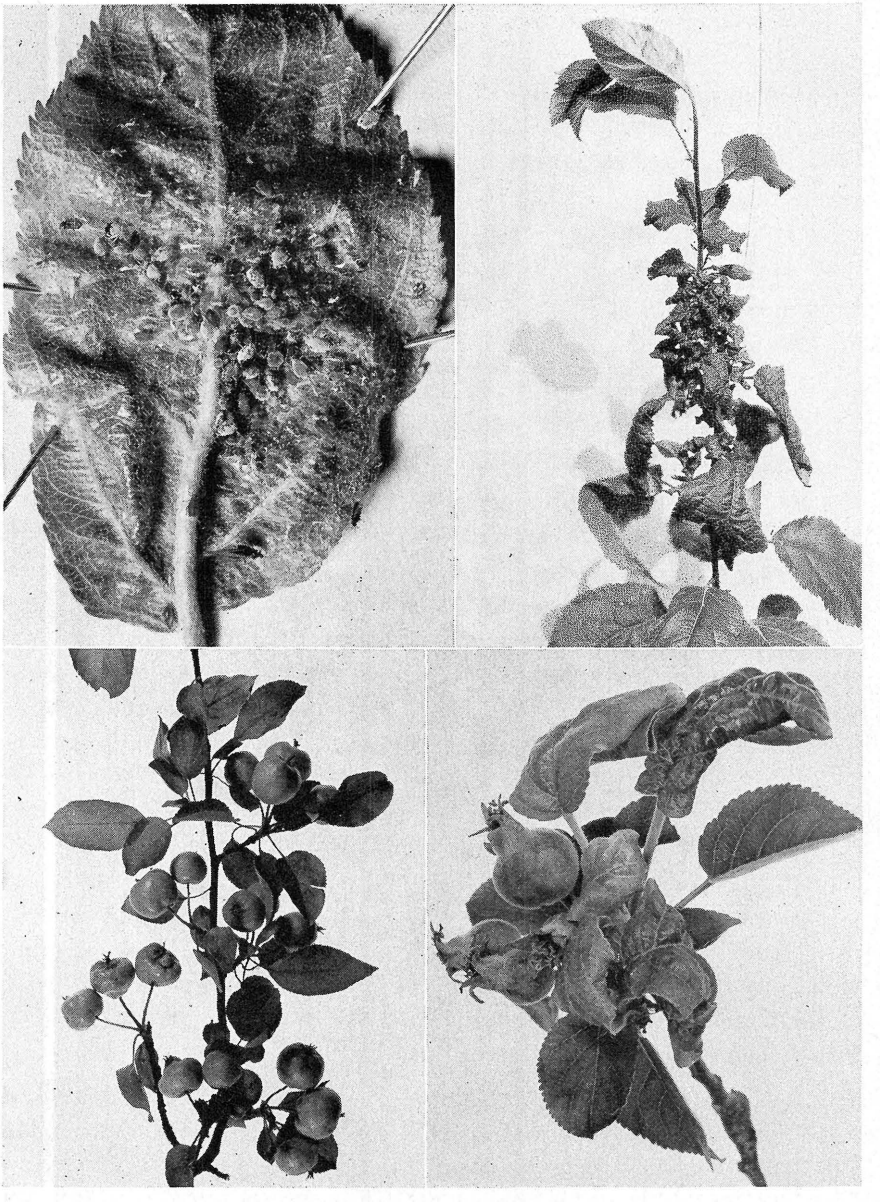


Plate III.—A. Leaf unrolled to show rosy apple aphid colony.
B. Injury by rosy apple aphid to leaves on water spout.
C. Small gnarled fruit caused by rosy apple aphid feeding.
D. Curled leaves due to rosy apple aphid feeding; young fruits also affected.

in color and appear as though a white powder had been sprinkled lightly over the body. (Plate III. Fig. A) Usually several hundred of the other green aphids can be counted for each one of the rosy aphids that are found. As they grow, practically all become slate colored. They move to the young leaves as soon as these unfold and there produce the tightly curled and distorted foliage that is so characteristic of injury by this species. The stem mothers become mature in about two weeks, as do those of the apple grain aphid, but are able to reproduce almost twice as rapidly as the latter. Also the species remain on the apple for one or two more generations before migrating. Thus, great numbers are occasionally found on trees during the month of June. During late June and early July the aphids of the third and fourth generations develop wings and leave the apple, going to different plantains where they spend the summer. A few colonies may be found on apple even in August but usually the trees are free from this species shortly after the first of July. The apple fruits are attacked by individuals of the second, third and fourth generations when crowding occurs on infested foliage. In their search for new food the fruits are found. Feeding by even a few aphids is sufficient to cause the gnarling and permanent dwarfing of the young apples. In autumn winged forms from plantain fly back to the apple and produce females that later deposit the overwintering eggs. The male aphids develop on plantain and later fly to apples where they find and fertilize the female before egg laying is started.

THE EYE-SPOTTED BUD MOTH SPILONOTA OCELLANA **(DENIS AND SCHIFFERMULLER)**

This insect deposits eggs on the undersides of leaves in late June, July and early August. The larvae feed on the foliage, usually protecting themselves by tying leaves together on the surface of an apple. Injury to the fruit is caused by a series of small punctures in the skin or occasional patch feeding. (Fig.12) The larvae overwinter in silken shelters in protected locations on the tree. In the spring activity is resumed and larvae frequently attack the buds (Fig. 13) as well as young foliage. Before pupation a full grown larvae will measure one-half inch in length, it is a chocolate brown color with a shiny, black head. Moths emerge in June and July, there being only one generation per year.

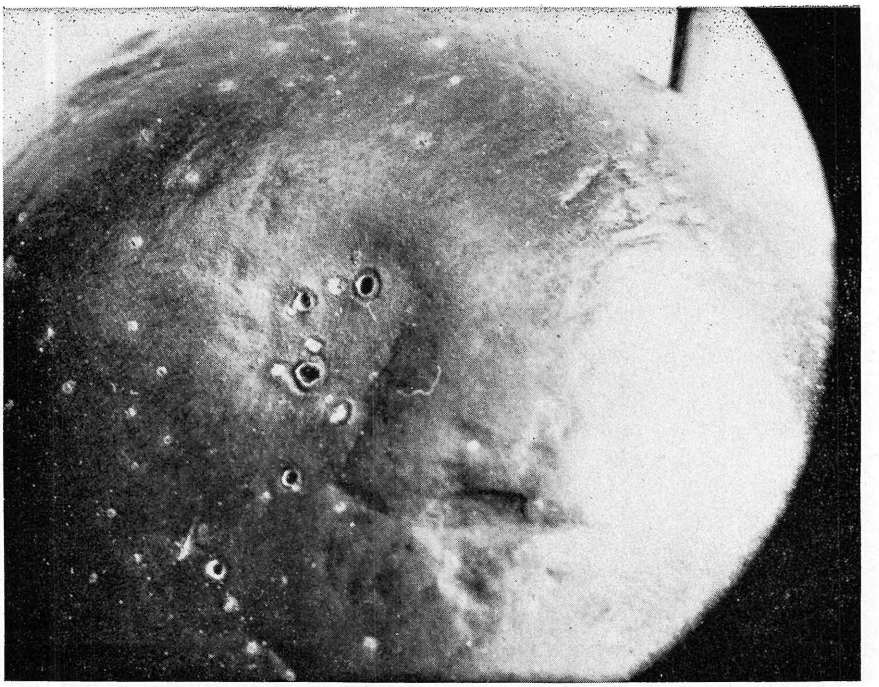


Fig. 12—Feeding injury to apple by larva of the eye-spotted bud moth. (Courtesy U.S. Dept. of Agriculture).

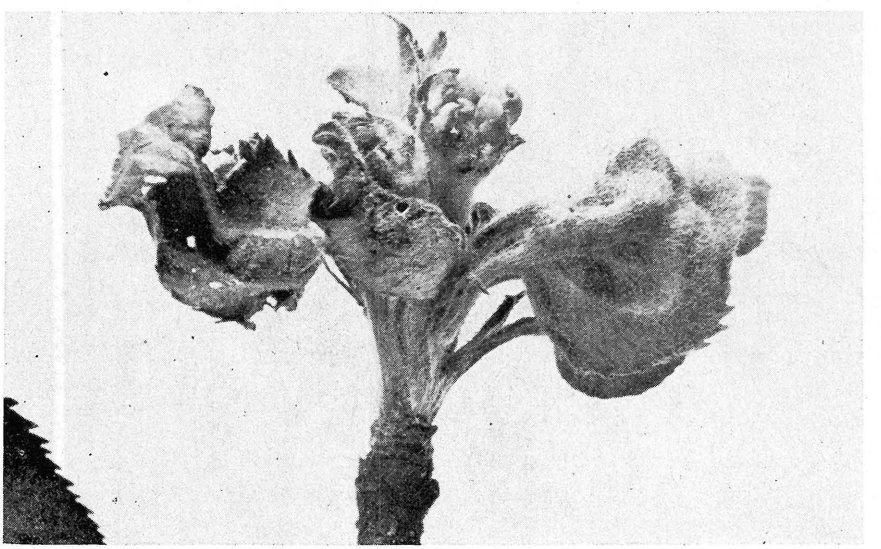


Fig. 13.—Apple blossom bud attacked by larva of the eye-spotted bud moth. (Courtesy U.S. Dept. of Agriculture).

THE GREEN FRUIT WORMS LITHOPHANE ANTENNATA **(WALKER)**
LITHOPHANE UNIMODA **(FLENNER)**

These and other related species (Fig. 15) are rather large green caterpillars that attack the young fruits and foliage especially in unsprayed or poorly cared for orchards. The characteristic feeding injury is found in May or early June and is a large pit in the side of the small apple. (Fig. 14) However, the commercial orchardist who follows a well planned spray program has little to fear from this pest.

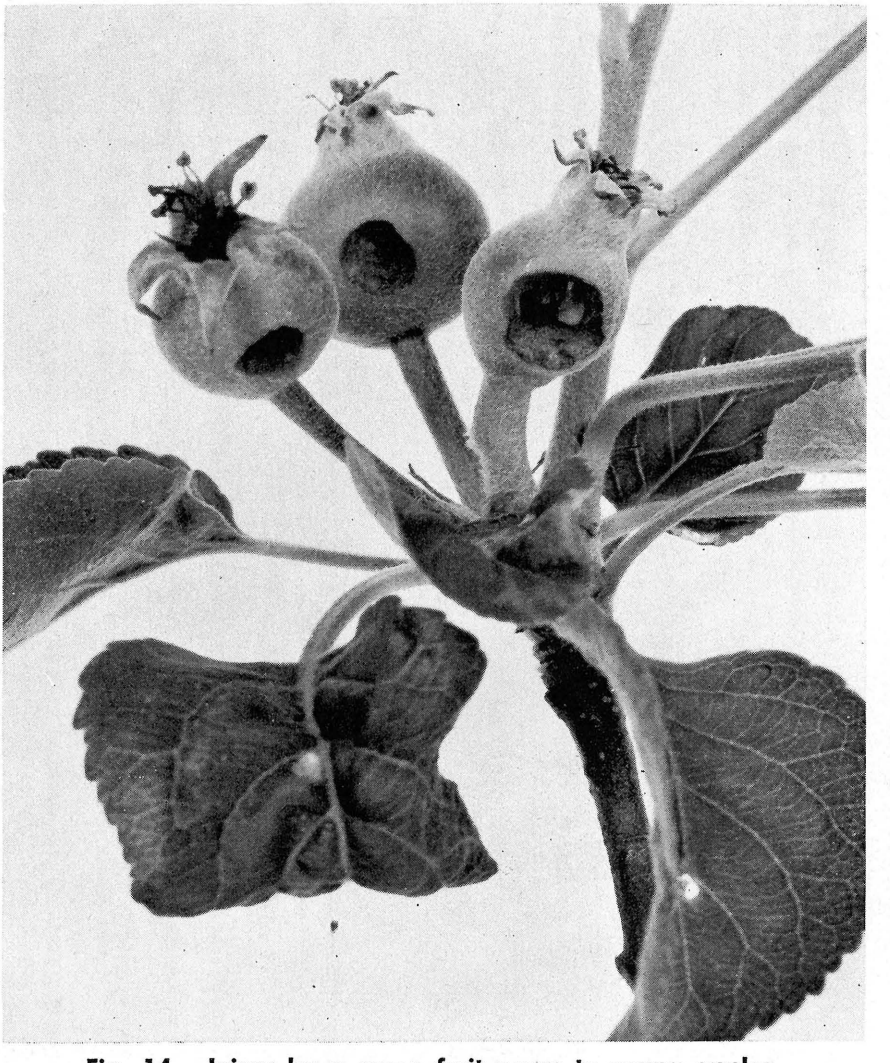


Fig. 14.—Injury by a green fruit worm to young apples.

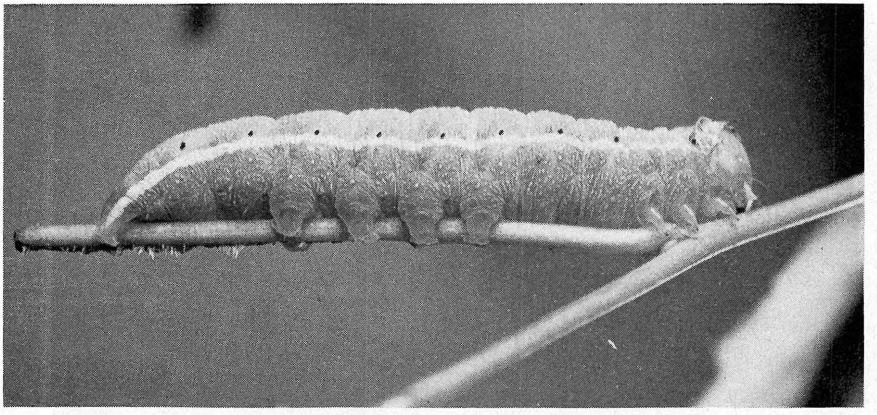


Fig. 15.—A green fruit worm - Lithophane unimoda **(Lintner)**

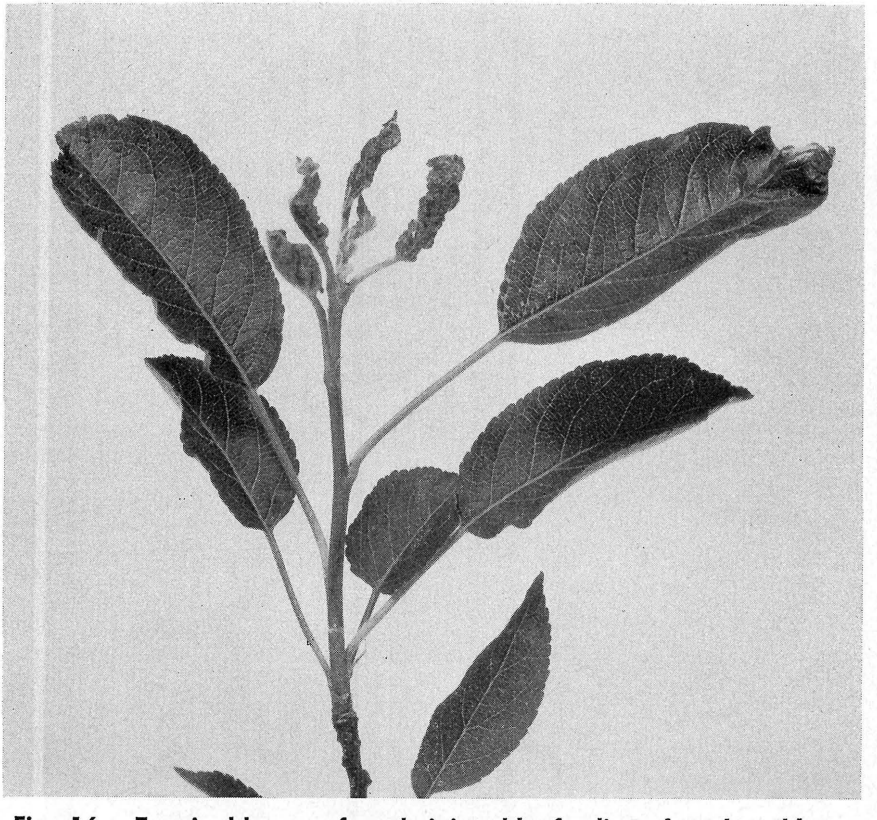


Fig. 16.—Terminal leaves of apple injured by feeding of apple red bug.

THE APPLE REDBUGS LYGIDEA MENDAX REUTER AND HETEROCORDYLUS MALINUS REUTER

Prior to the introduction of DDT and the organophosphates as orchard sprays the apple redbugs were serious pests in numerous orchards in northern Ohio. This is no longer the case as injury is now rarely reported. Both species overwinter as eggs in the bark. Hatching starts when buds are in the pink and continues during the bloom period. The young are bright red in color and run rapidly about, especially when disturbed. They feed on terminal leaves which become crumpled and covered with small brown specks and tiny holes. (Fig. 16) By far the greater injury, however, occurs on young fruits where the skin has been punctured. This causes dimpling, deep pitting, and general distortion of the fruit. Adults appear in June and egg laying will extend into July. There is only one generation per year.

Related to the redbugs are several species of plant bugs which occasionally feed on tender apple growth, blossom buds and fruits. Several species of stink bugs may also feed in the same manner. Injury caused by members of these two groups may result in malformation of the tips of new growth, the destruction of buds, and deep narrow pitting in the fruits, which usually are without other distortion. Fortunately all these injuries are rather rare on apple.

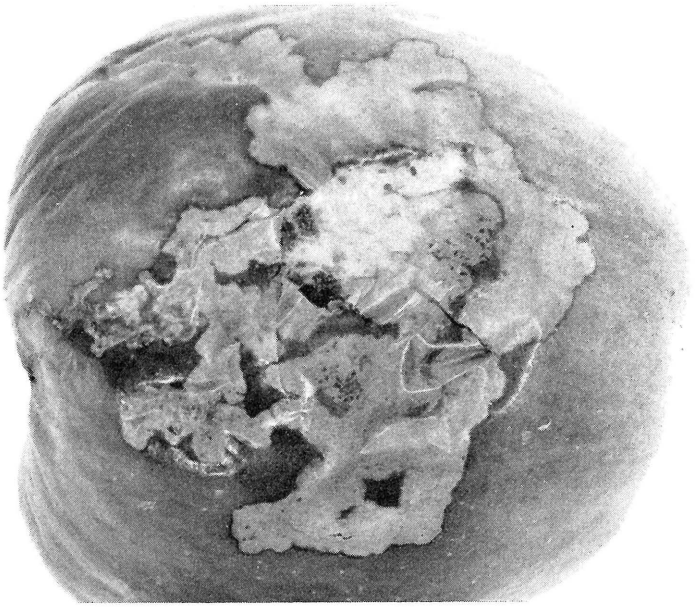


Fig. 17.—Apple injured by the lesser apple worm.

THE LESSER APPLE WORM GRAPHOLITHA PRUNIVORA **(WALSH)**

In its life history and general habits this insect closely resembles the codling moth. In size, however, all stages are smaller. The injury to apples is different in that the apple worm larva does not penetrate the fruit as deeply as does the codling moth larva. It usually works just under the skin, which is left intact and turns gray thus accentuating the injury. (Fig. 17) This insect and its injury are rather rare in Ohio.

THE APPLE SEED CHALCID TORYMUS DRUPARUM **BOHEMAN**

Most chalcids are parasites that attack and live at the expense of other insects. This very-small, wasp-like species deposits its eggs in apples (Fig. 18) and related fruits and the larvae feed on the seeds. (Fig. 19) Fruits so attacked are pitted and generally malformed. It is occasionally found in northeastern Ohio but is of minor importance.

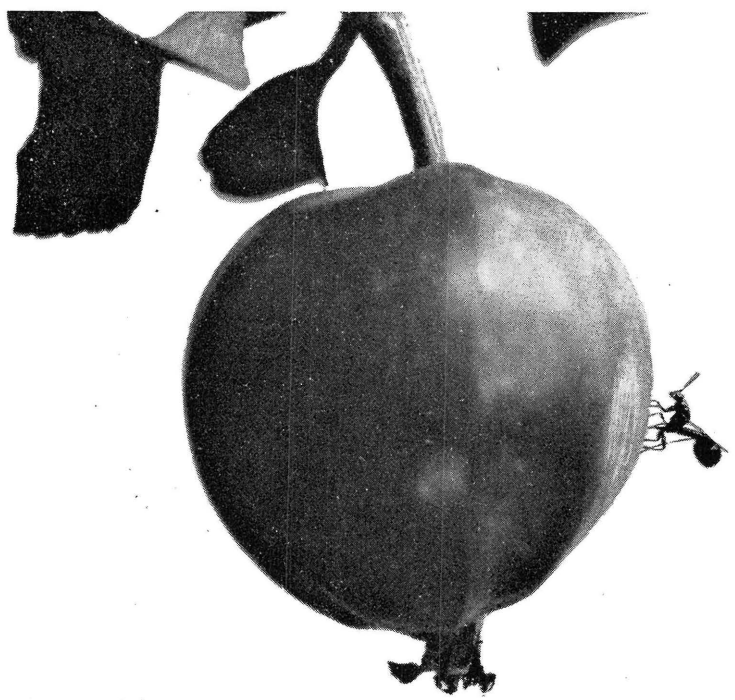


Fig. 18.—The apple seed chalcid ovipositing in young apple. (Courtesy U. S. Dept. of Agriculture).

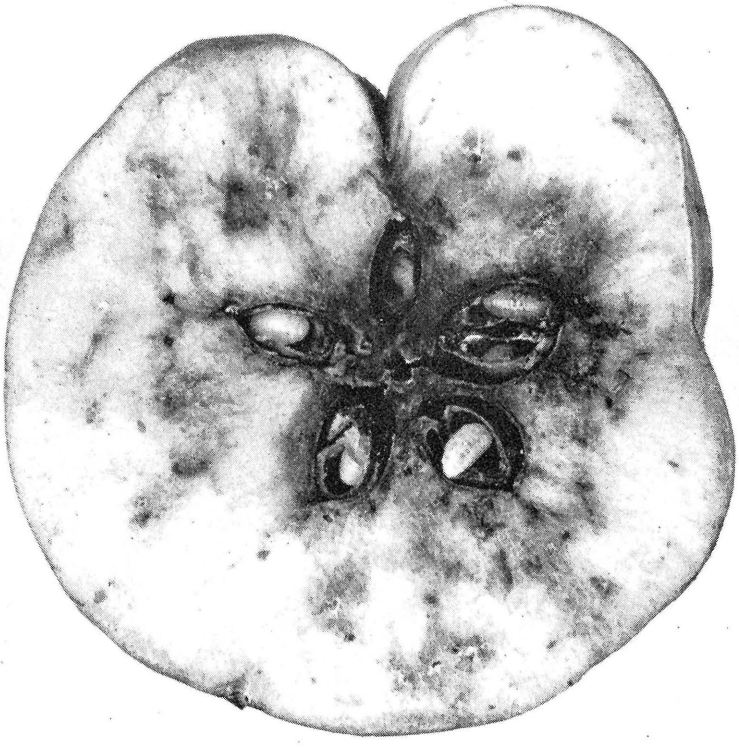


Fig. 19—Apple injured by the apple seed chalcid whose larvae are shown feeding in the seeds. (Courtesy U. S. Dept. of Agriculture).

THE ROSE CHAFER MACRODACTYLUS SUBPINOSUS **(FABRICIUS)**

This beetle is a general feeder and may be found attacking all fruits as well as ornamentals and flowers. The larvae which have fed underground on the roots of plants during August and the autumn months go below the frost line to spend the winter. In the spring, feeding is resumed but the larvae soon become full-grown and pupation occurs in early May. The beetles emerge from the soil in late May and early June. Feeding (Plate IV A) by the adult, mating and egg laying extend into July. The adult beetles are light tan in color, with long legs, and are about one-half inch in length. They are gregarious and are frequently found "balled up" (Plate IV B) on their food. It is this habit that frequently attracts attention to them.

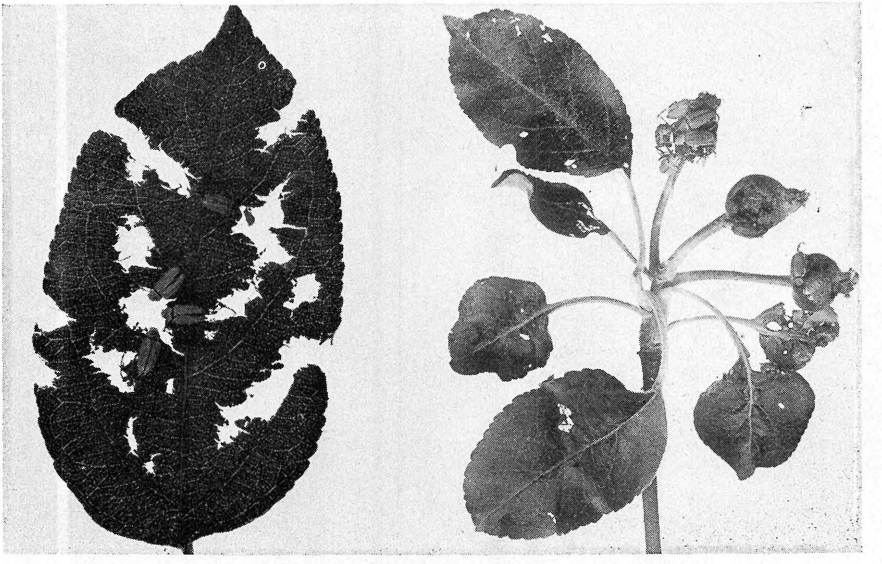


Plate IV.—A. Rose chafers feeding on apple leaf.
B. Rose chafers attacking young apple fruits.

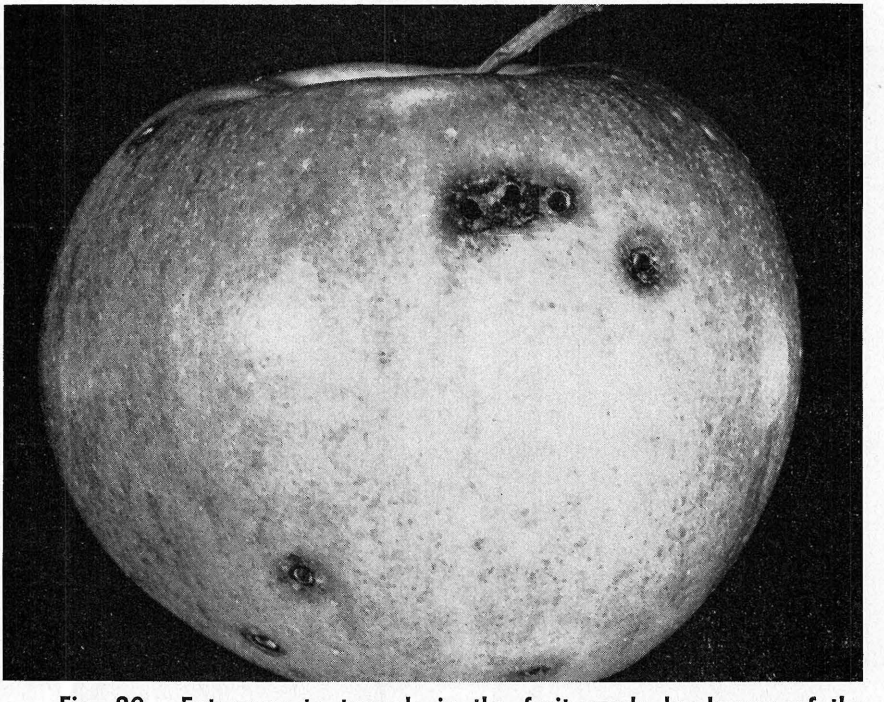


Fig. 20.—Entrances to tunnels in the fruit made by larvae of the dock sawfly.

THE DOCK SAWFLY AMETASTEGIA GLABRATA (FALLEN)

During the autumn months a green larva, about one-half inch in length, may occasionally be found burrowing into apple fruits. During the summer these larvae feed on the leaves of dock or related plants but in the fall, when mature, they seek hibernating quarters in weed stems, soft bark, or even in the fruit. (Fig. 20) They are very sporatic but occasionally are noted in numbers sufficient to cause concern. Keeping the orchard well mowed is an aid in control.

THE JAPANESE BEETLE POPILLIA JAPONICA NEWMAN

This is an imported insect having been brought to this country prior to 1916. It was first noted in injurious numbers in New Jersey from which area it has spread to most states east of the Mississippi River.

The larvae overwinter in the soil below the frost line. In the spring they move upward and feed upon the roots of grasses, weeds and other plants. Pupation starts about late May or early June and the adult beetles emerge about one month later. The various activities of the adults will continue for about two months. Egg laying occurs in the soil and may start about mid-July. Hatching and larval

Fig.21.—Japanese beetle feeding on fruit at right of center and feeding on foliage at left.

feeding begins about two weeks later and feeding will continue until the advent of cold weather. There is only one generation per year.

The larvae, which are of the white grub type, are severe pests of turf, but the injury done by beetle feeding attracts most attention. The beetles are nearly one-half inch long and are metalic green with copper-colored wing covers. They attack the flowers, fruits and foliage of many species of plants, being particularly fond of grape and sassafras leaves. They are gregarious and the plant on which feeding starts will usually suffer severe injury due to this habit. (Fig. 21)

Though the Japanese beetle has been well established in certain areas in Ohio for many years it is only recently that it has become a general pest over the eastern part of the state. It is possible that in certain areas and at certain times that it may be a serious pest of fruit although present indications are that good commercial spray programs will give adequate control.

ATTACKING BUDS AND FOLIAGE

MITES

Mites are not insects but belong to a closely related group called the Arachnida which includes spiders, ticks, scorpions and harvestmen as well as the mites. All arachnids have two body regions instead of the three possessed by insects. When mature they have eight legs instead of six as in the case of insects. Mites attack many different hosts such as plants, animals, insects and other mites. Among those that attack plants, some feed in the open while others cause the formation of galls which give them protection. Numerous species are found on apple but only the three most important species in Ohio will be considered here.

THE EUROPEAN RED MITE PANONYCHUS ULMI (KOCH)

As indicated by its name the European red mite is not a native of the United States. The exact dates of its introduction into our country and into the State of Ohio are not known. However, definite reports of injury caused apparently by this species were made in 1917-18 for peaches in Ottawa County, Ohio, and in 1919 on apples near Youngstown, Ohio.

Injury: Damage by the European red mite is confined almost entirely to the foliage. By the piercing action of the mites' mouth parts, the tissue of the leaves are broken down and the cellular contents including the chlorophyll are ingested. If feeding is extensive, this will cause the bronzing of the foliage and its loss of normal function. This will result in smaller fruits of low quality and weakened

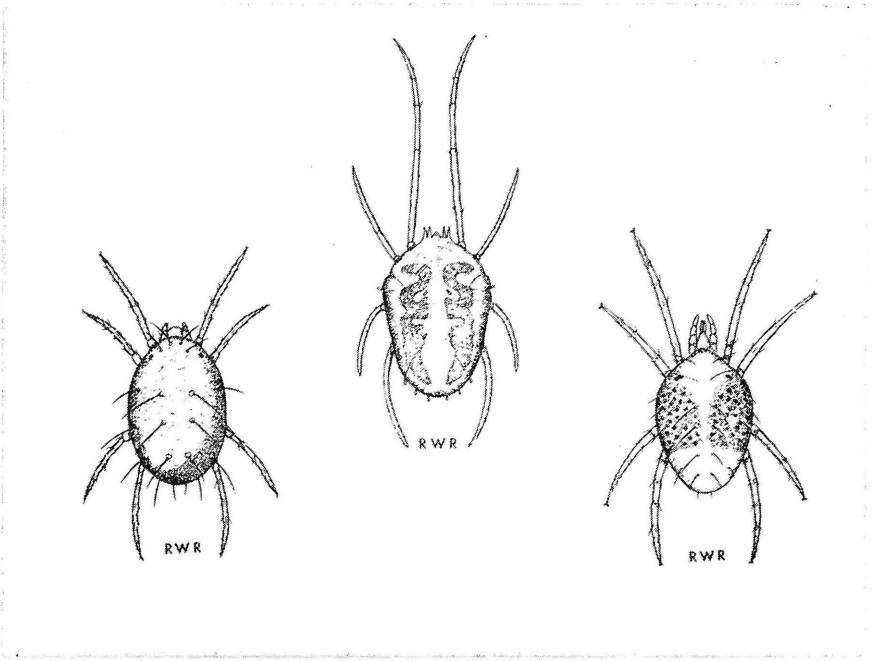


Plate V.—Adult females of (left) the European red mite, (center) the clover mite, (right) the two-spotted spider mite.

fruit buds for the crop of the coming year. In fact, if severe injury occurs early in the season, that is, before July 1, fruit bud formation may not occur.

If leaves are only partially injured, they may recover their normal color and function if the mite population is destroyed. However, if the damage is severe, there is no recovery and the leaf becomes almost useless. Severe defoliation may occur in dry seasons. In Ohio, Red Delicious is the most susceptible variety, but no varieties are immune. Apples generally suffer more injury than other fruit trees with the possible exception of European plums.

Life History: Mites of this species overwinter as eggs on the twigs and branches of apple, plum, pear, and peach. Eggs may occasionally be found on other hosts such as crab apples, elm, cherry and wild cherry. They are located principally around rough areas on the twigs including the bases of spurs, points where new growth has started, and pruning scars or injuries. The vast majority of the eggs are on the undersides of the branches in the locations noted. The number of eggs found in any roughened spot may vary from 1 to 500

or 1000 on the larger areas. Thus a heavily infested tree may carry hundreds of thousands of eggs. Eggs are of much interest to the economic entomologist because their exposed position makes them a relatively easy target for early season spraying. The eggs are very small, globular and vary from bright to dark-red in color.

The first hatching of eggs usually occurs when the blossom buds of Red Delicious show pink. This occurrence of course varies widely from year to year depending on temperature, sunshine, rainfall, and other conditions. At Wooster the earliest date of hatching of the overwintering eggs was March 31, 1945, and the latest was May 6 in both 1940 and 1950. The latest hatching of overwintering eggs has occurred as early as April 20, 1945, and as late as May 23, which occurred in three seasons, 1947, 1948 and 1956. Peaks of hatching occurred at the earliest, on April 10, 1945, and as late as May 11 in both 1947 and 1956. The period of egg hatching has been as short as 9 days (1939 and 1951) and as long as 30 days (1946).

In spring, the time necessary for growth of the newly hatched mite to maturity and start of the period of egg production is about two weeks. After egg laying begins, the average female will live about the same length of time. Later in the season as temperatures become higher the time required for development is less. There is usually a short period between the final hatching of the overwintering eggs and the first egg laying by first generation adults. This period during which no eggs are present on the trees is a favorable time for spraying since the living mites are more susceptible to a number of different spray chemicals than are the eggs. The time of the scheduled spray that most nearly coincides to this period is that of the "Pink" spray. It is for this reason that spraying mites at this time is recommended if dormant or delayed dormant sprays were not applied.

Egg deposition by first generation females starts about the end of the blossoming period and may continue for as long as two weeks. For the brood as a whole, oviposition may not be completed until about three weeks after petal fall. The length of time required for all the overwintering eggs to hatch is aways less than that needed for eggs of the first generation. As this general pattern is repeated and enlarged upon for each succeeding generation it results in overlapping of the broods so that by mid-summer there is no distinction as far as the different generations are concerned. In fact, different broods may all be living together on the same tree or even on the same leaf. (Fig. 22)

As the season progresses and summer temperatures prevail the time necessary for the growth and completion of a generation is less

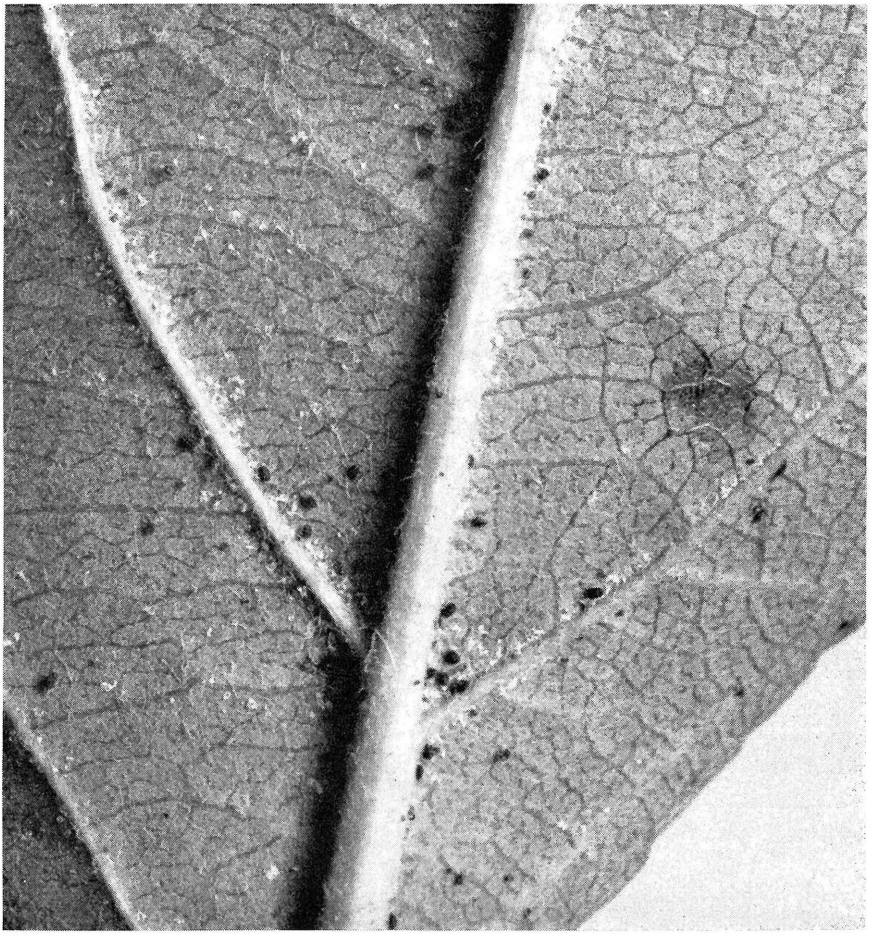


Fig. 22.—European red mites on the underside of apple leaf.

than in the case of the early-season broods. In general a statement could be made to the effect that each generation occupies about a month. This, however, does not take into account the fact of overlapping so that in Ohio the early generations would occupy less time than this while the later ones would need more. This means that in northern Ohio there are at least five complete generations and a partial sixth, seventh and eighth.

The relatively short time necessary for the development of a complete generation, plus the number of generations possible each season, indicate the great potential of the European red mite to produce in-

festations of damaging numbers. Also the fact that each individual female will produce an average of 20 to 30 eggs further emphasizes this point. By a simple process of arithmetic it can be shown that a single pair of mites of the first generation can multiply to a number of over one half million in the fifth brood. Therefore, if a tree started the season with a population of 10,000 mites, which is a reasonable figure, the possibilities of an early and destructive infestation are great unless natural or man-made controls intervene.

Natural Controls: Certain weather conditions as well as predaceous enemies and disease are considered to be natural controls.

Various types of winter weather seemingly have little effect on mite eggs. It is known that when ice on the twigs breaks away that it may carry with it some eggs but, other than this, no effects even of severe cold have been noted. Newly hatched mites, however, are susceptible to cold. Therefore, if frost occurs in the spring shortly after eggs have hatched a high mortality will result. Such a period of cold weather occurred May 8-12 in 1960 and was a factor in the early season control of mites for that year. Dashing rains will wash some mites from the foliage but is rarely a factor in control. Cool, rainy, and cloudy weather slows down reproduction and in seasons where this type of weather predominates it plays some part in the alleviation of infestations. However, severe infestations have occurred in cool, rainy seasons. In other words, the various weather factors are not too important when it comes to controlling the European red mite.

Of much more importance is the control that may be effected by predaceous enemies which include certain species of predaceous mites, thrips and lady bird beetles. On trees where no chemical sprays or dusts are used predators practically always keep the European red mite under control. This phenomenon has been noted after spraying has been discontinued in an orchard, both in late season, when only early sprays were applied, and in orchards soon after abandoment. Unfortunately in orchards where only early season sprays were used a period of damage always occurs before the predators gain the upper hand.

Chemical and Mechanical Controls: Mechanical controls, that have been devised by man, include the syringing of infested plants with water under pressure to dislodge mites, and the use of glue, latex, and other "sticky"materials in varying amounts of water, to entangle them. In general, however, mechanical controls are ineffective and are little used.

The use of chemicals, especially those materials that are efficient miticides, is the advised and most effective method of immediate control. With our present system of controlling insects, disease and other pests with spray chemicals, this type of control must also be used against mites. However, it should be understood by all that the difficulties with mites are largely the results of spray chemical usage for the control of other pests. There are two reasons for this: First, the use of an effective miticide will so reduce the population of mites that food is not available for the natural enemies. Therefore, these predators must leave the treated trees or starve. In either event, the few remaining mites multiply unchecked and as already pointed out this results in damaging populations in a very short time. The second reason that chemical usage promotes mite outbreaks is the fact that many of our present day insecticides kill tremendous numbers of mite predators, thus releasing the injurious mites from this natural control. Nevertheless, our present effective system of insect and disease control demands the use of chemicals, and these materials must also be used against mites.

History of European Red Mite Control in Ohio: The first experimental control work in Ohio on European red mite was done by J. S. Houser in the Chestnut Hill Farms' Orchard in 1920 at Youngstown. It was found that Scalecide, a proprietary oil spray, gave excellent control when applied early in the season. Other experiments conducted from 1921-25 showed that other oils, particularly those of the "red engine" oil emulsion type gave equally good results. At first it was thought that the single application of oil in the dormant or delayed dormant period would give control for the entire season but by 1927 it was recognized that mite damage could occur in late summer despite the early season use of oil. This led to experiments with summer oils in 1928 which showed that application of such oils in July and August would control mites, but that some injury to foliage and fruit was caused by their use. From 1929 to 1934, the European red mite was not a serious problem and no experimental control work was conducted. However, damage again occurred in 1936 and experimental work was resumed. Either control or biological investigations, or both, have been carried on each year since that time. Control work from 1939 to 1940, inclusive, dealt mostly with early season trials of different oils, tar oil washes, and dinitros such as Elgetol. Petroleum oils were more efficient than the other two. In summer spraying the numerous forms of sulfur were employed without any outstanding results.

Oils of different types were also tested but damage to fruit and foliage frequently occurred when enough oil was used to be effective. In 1940, rotenone sprays used with small amounts of oil or with an effective spreader-sticker were found efficient. This marked the beginning of successful summer spraying against the European red mite although war conditions and cost soon rendered rotenone or derris unavailable. The summer dinitro (DN-111) was first recommended for use in 1943, and Dry Mix No. 1 in 1947. Also in 1947, the first experimental work was done with dimite and the early organophosphate, HETP. TEPP and parathion appeared in 1948, and EPN in 1949. From 1950 to 1960, inclusive, many new acaricides were introduced. In 1952, malathion, demeton (Systox) and Diazinon appeared. Aramite and ovex were introduced in 1953. In 1955, genite and Chlorobenzilate, and in 1956, mitox, Kelthane, Thimet, Trithion, Phosdrin, and Guthion were first used. In 1957 and 1958, Delnav, ethion, Tedion and phosphamidon appeared. As of 1962, many of the newly introduced acaricides are still effective but the petroleum oils are the only materials that have had long usage and are still recommended.

Resistance: The most serious current problem in connection with the control of mites is that of resistance. Resistance is the result of an artificial selection that starts when any control measure is applied against a population of mites or other organisms. In any population there are individuals that are "stronger" or possess certain genetic factors that enable them to resist or escape the control action. Thus, when the control is repeated against their progeny, an ever increasing number carry these same factors and in time practically all of the surviving population become resistant. It has been definitely shown that most of our spray chemicals, when used continuously, will produce resistance on the part of the European red mite in a period of from 2 to 4 years. Some of our most effective miticides, such as parathion, malathion, demeton, EPN, ovex and others have been rendered useless by this process.

To delay and possibly avoid the resistance problem, the rotational use of miticides with different killing actions is recommended. Details regarding such usage, as well as listings of the most efficient miticides, are to be found in the current literature of 1961-1962.

THE TWO-SPOTTED SPIDER MITE TETRANYCHUS TELARIUS (LINNAEUS)

This species is usually not too abundant on Ohio apples but at times it may cause serious injury. Low hanging branches that touch grass or weeds are usually first attacked after which mites spread up-

ward and to the interior of the tree. Injury to the leaves resembles that of the European red mite except that a grayish cast is more prevalent. The mites also spin a fine silken web over many infested leaves.

The eggs of this species are very small, spherical, and very light greenish-yellow or pearly-white in color. The mites are usually a very pale green in summer with two dark spots, one on either side of the abdomen. In autumn, prior to hibernation, the adult females assume a reddish-orange color.

Life History: Full grown female mites, and some immatures, overwinter under bark scales on the trunk of the tree or among fallen leaves and in other protected places on the ground. With the arrival of warm weather in the spring, these mites leave their places of hibernation and start wandering about looking for food plants. Almost all of those on the tree trunk crawl down the trunk to the ground where they feed on weeds and grasses. The first eggs can usually be found before May first. In warm weather, these hatch in five to eight days. A complete generation from egg to adult may require no more than three weeks. Therefore, from five to nine generations may be expected in the orchard each season. Their preference for low growing grasses and weeds is one of the main reasons that Ohio trees escape to the extent that they do.

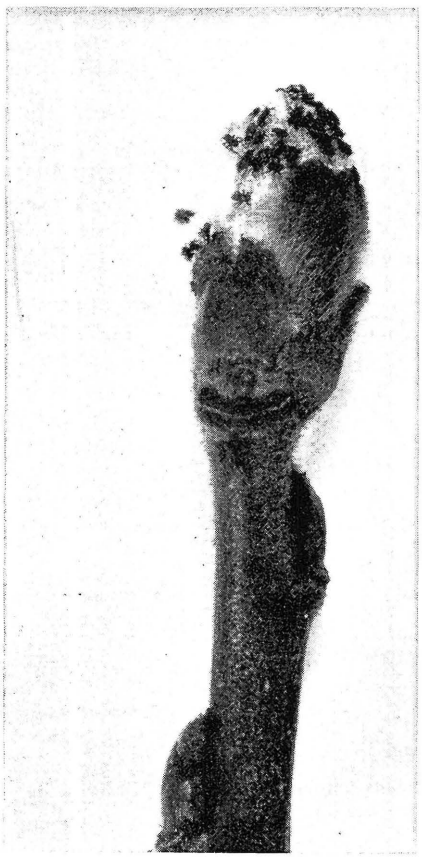
However, in mid or late summer when drought and other factors cause poor food conditions among weeds and grasses, mites move from the old hosts up the tree trunks or to low hanging apple branches where these are in contact with the ground vegetation. Once established, this population may devevlop into a serious infestation as already indicated. The arrival of cold weather causes the mites to seek quarters for hibernating.

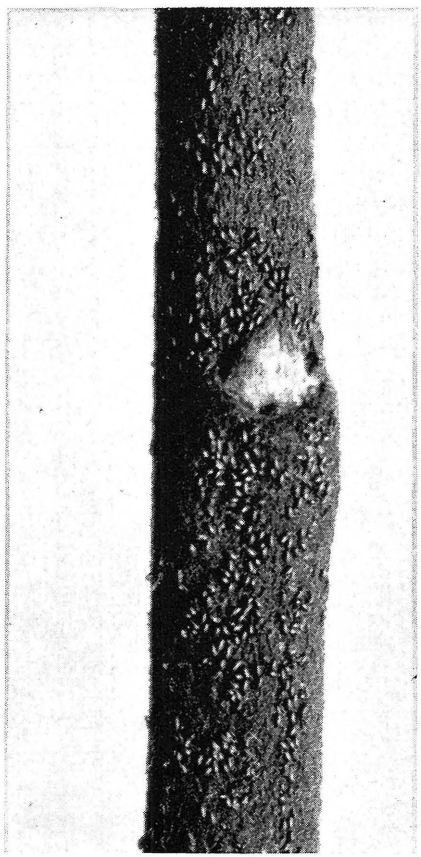
THE CLOVER MITE BRYOBIA PRAETIOSA KOCH

This species is best known in Ohio for its habit of invading houses in the autumn when it is seeking winter quarters, and in spring when it leaves them in search of food. These mites are slightly larger than the other species, but are still quite small. They are brown in color and have unusually long fore legs. In Ohio, they may overwinter both as eggs on the twigs and branches of apple and other trees and as adults in sheltered places, both indoors and out. They are general feeders and attack fruit and other trees, clovers, grasses and many other plants and shrubs. In Ohio, they are only an occasional pest of apple, usually on poorly sprayed or untreated trees. The species is found most frequently in the southern part of the state. The eggs are spherical, bright red, and closely resemble those of the European red mite.

APHIDS

The aphids or plant lice are sucking insects which derive their nourishment from the sap or juice of the host plant. They are small but by no means microscopic in size. Their bodies are without armor and their only defense is the great rapidity with which they reproduce. The biology of the different species vary greatly in that there are many different patterns of reproduction, migration and host reaction. They are attacked by many different parasites and predators. Numerous species have been found infesting apple buds and foliage but in Ohio only four are commonly known.





Figs. 23 and 24.—Apple bud covered with young of the apple grain aphid (Rhopalosiphum fitchii **(Sand.) Eggs of the apple aphid on apple twig.**

Fig. 25.—Apple terminal infested by the apple aphid, Aphis pomi **DeGeer.**

THE APPLE GRAIN APHID RHOPALOSIPHUM FITCHII **(SANDERSON)**

This is the species that is so conspicuous in early spring on the swollen fruit buds of apple. (Fig. 23) The eggs of the other aphids on apple have not yet hatched in any number; therefore, the grower can be quite positive as to the correct identification of this small, dark green species. Later, when this aphid is to be found on the leaves

around flower buds or flowers, it develops a dark green line running down the middle of the back with four or five cross lines of the same color. The general body color is light green.

Life History: The winter is passed in the egg stage, on the bark of slow growing terminals, fruit spurs, or on larger branches. The small, glistening, oval black eggs are usually placed about buds or other rough areas on the bark. They hatch earlier in the spring than the eggs of other species and are always far more abundant. Eggs have been noticed hatching as early as March 3 at Wooster but this, of course, was due to abnormally warm weather in that particular season. In northern Ohio, maximum egg hatch occurs during the first two weeks in April; while in the southern part of the State this may be expected to occur from one to two weeks earlier. The newly hatched aphids do not withstand cold weather well and numerous individuals will be found dead after periods in which the temperature falls below 22° F. With normal spring temperatures prevailing, the young aphids, or stem mothers as they are called, grow and become mature in about two weeks. In one or two days after becoming mature the stem mothers begin their reproduction processes. Stem mothers are parthenogenetic, that is, they are able to reproduce in the absence of male aphids. Instead of laying eggs the stem mothers bear living young. The number of young to which each stem mother may give birth varies greatly, but according to authorities it averages from 70 to 100 per individual. During their period of growth most of the young of the second generation develop wing pads and at maturity become fully winged. The few aphids that do not become winged produce a third generation, all of which develop wings. The first of the winged forms leave the apple as the petals start to fall and migration continues for about two weeks, at the end of which time none of the apple-grain aphids are to be found on the trees. The plants to which the migrants fly are different cereals and grasses, and on these the aphids produce several more generations during the summer months.

In the autumn, winged forms develop on the grains and grasses and later return to the apple. The first of these may appear on apple in early September, and arrivals continue into November. After establishing themselves on the foliage, they give birth to young aphids that develop into sexual female forms. Winged males that have developed on cereals and grasses now fly to apple and fertilize the females, after which the overwintering eggs are deposited as has already been described. The bulk of egg laying occurs during late October and early November.

Fortunately, this aphid, even though it appears in tremendous numbers, does little damage to the apple. It does not attack the fruit and its feeding on the foliage causes little or no distortion.

THE APPLE APHID (FORMERLY THE GREEN APPLE APHID) APHIS POMI DEGEER

The apple aphid is by far the most abundant summer species in in Ohio and, as such, attracts more attention and causes more injury than any of the other plant lice on apple. This is the species that is so abundant during June and July on young trees, water sprouts, and vigorous growing terminals. (Fig. 25) It curls the foliage and covers it and the fruit with honey dew on which grows a black sooty fungus. At times this causes considerable discoloration especially of early apples.

Life History: The insects overwinter as small, shiny, black eggs (Fig. 24) on water spouts or terminals that have grown until late in the season. The leaves about the fruit buds have started to unfold when the first eggs hatch, and thus offer a favorable food to the young aphids. In a little over two weeks these stem mothers mature and then start to reproduce. The reproductive period lasts nearly a month and each female will produce an average of 50 living young. In the case of the other aphids discussed, the winged forms do not appear in numbers until later generations. However, in the case of the green aphid the great majority of this generation become winged and fly at once to new locations. Some of the winged aphids fly to any of a large group of plants which serve as summer hosts but most seem to fly to other apple trees where they settle on new growth and start new colonies. These movements may start as early as the middle of May, at Wooster, and maximum flight occurs usually by June 1. These dispersing aphids will not reproduce to any extent except on new and succulent growth. If they alight on old foliage they soon leave it and continue the search for suitable food. During the summer months numerous generations occur on apple and these follow each other in rapid succession until the slowing down of growth in the trees creates unfavorable food conditions. When such conditions occur a much greater time is required for a generation to complete its development. Dispersal by winged forms from one tree to another occurs during almost the entire summer. In August and during the autumn months the species is found almost entirely on water sprouts or terminals of young trees that are still growing, and it is in such locations that the sexual forms are developed and the overwintering eggs deposited.

This species is heavily attacked by its natural enemies, such as lady-bird beetles, syrphid fly larvae, green and brown lace wing flies, and different parasites. Despite this and the many efficient spray materials that may be used against them, they are always a threat as long as the trees are in vigorous growth. This is, of course, due to their tremendous ability to reproduce. Since they are so dependent on new and vigorous growth, the water sprouts in the center of the tree are usually the center of infestation. The prompt removal of these water sprouts as they appear during the summer is a decided aid in control.

Fig. 26.—Apple blossom bud destroyed by larva of the pale apple leaf roller.

THE PALE APPLE LEAFROLLER PSEUDEXENTERA MALI **FREEMAN**

In the early spring of 1948, small greenish to white lepidopterous larvae were found attacking fruit buds (Fig. 26) in orchards covering the Little Hocking area south of Marietta, Ohio. Damage was severe and in one orchard from 50 to 75 percent of buds on the Rome variety were destroyed. Moths reared from these larvae were later identified as those of the pale apple leafroller, previously reported only from New York and Canada. The moths appear very early in spring and eggs are laid singly on twigs, even before the buds open. The larvae appear as the buds are expanding and these buds are destroyed by the small caterpillar boring into them. There is some feeding on foliage. Some damage was reported in the spring of 1949 but since that time the species has not been noted in Ohio.

THE WHITE-MARKED TUSSOCK MOTH HEMEROCAMPA LEUCOSTIGMA **(SMITH)**

The easily identified larvae of this species (Fig. 27) usually feed on the foliage of forest and shade trees. However, they occasionally attack apple leaves and at times feed on young fruits. This injury is usually due to surface feeding but at times pits are eaten out which resemble those caused by the green fruit worms.

THE FALL CANKER WORM ALSOPHILA POMETARIA **(HARRIS)**

This species belongs to the measuring worm or Geometrid family of moths. The larvae feed on the leaves of apple and many other trees. Most of the moths of this species emerge in November or early December and the wingless females (Fig. 28) deposit eggs at this time. These eggs (Fig. 28) individually resemble a small keg and are arranged in regularly aligned masses which may contain as many as 100 eggs. These are placed on the twigs and bark of larger branches. A few moths may delay their appearance until warm periods in the winter and occasionally some will appear in early spring. These females also lay eggs which hatch about the time that buds open. Severe damage and defoliation may be noticed as early as petal-fall on apples. When mature the larvae are slender, green worms with a white stripe on either side. In addition to the fleshy prolegs on the sixth abdominal segment a less prominent pair occur on the preceding segment. The larvae are about one inch long. (Fig. 29) Pupation takes place in silken cocoon in the soil.

THE SPRING CANKER WORM PALEACRITA VERNATA **(PECK)**

The life history and the habits are much the same as those of the fall canker worm except that the moths do not emerge until spring after

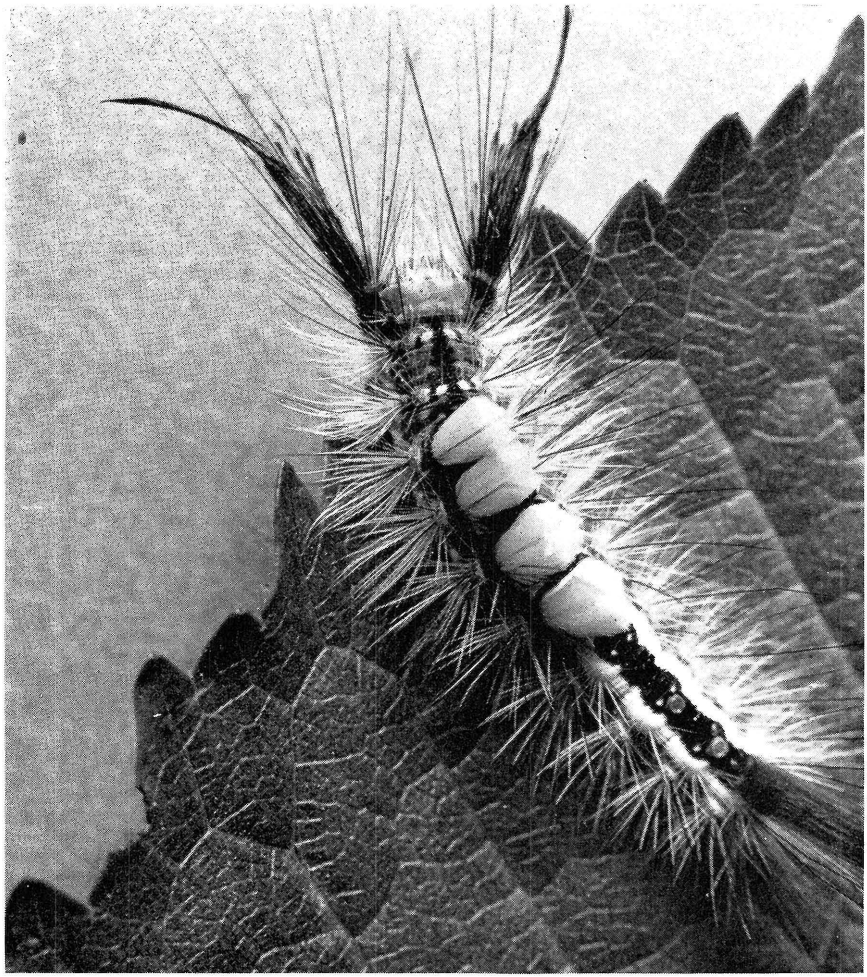


Fig. 27.—Larva of the white-marked tussock moth.

which oval eggs are deposited in loose and irregular clusters in protected places on the tree. (Fig. 30) The larvae are about the same size and shape as the other species but the white lines are on the back and the general color is brown. The wingless female has two rows of red spimes on the abdomen. Pupation takes place in the soil.

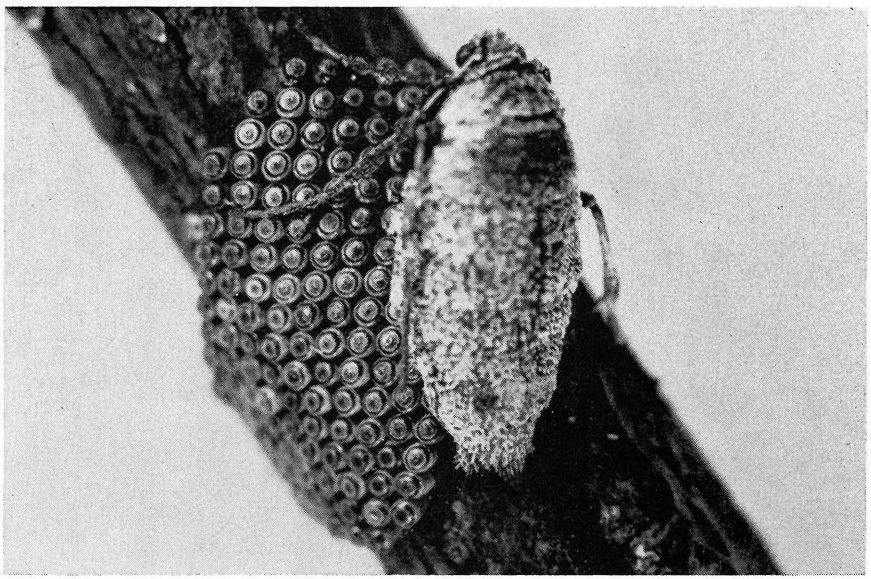


Fig. 28.—Adult female and egg mass of the fall canker worm.

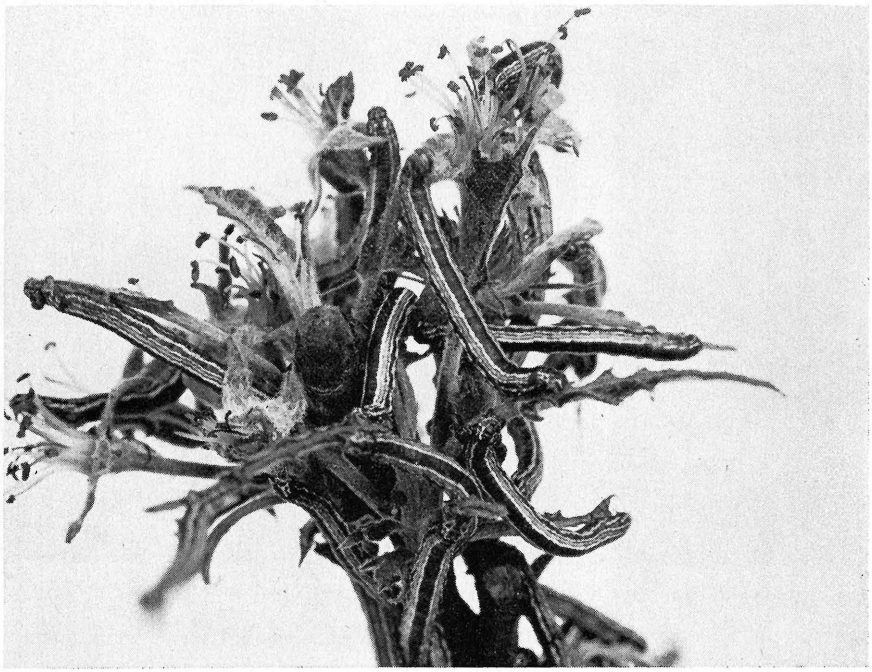


Fig. 29.—Larvae of the spring canker worm feeding on apple blossoms and leaves.

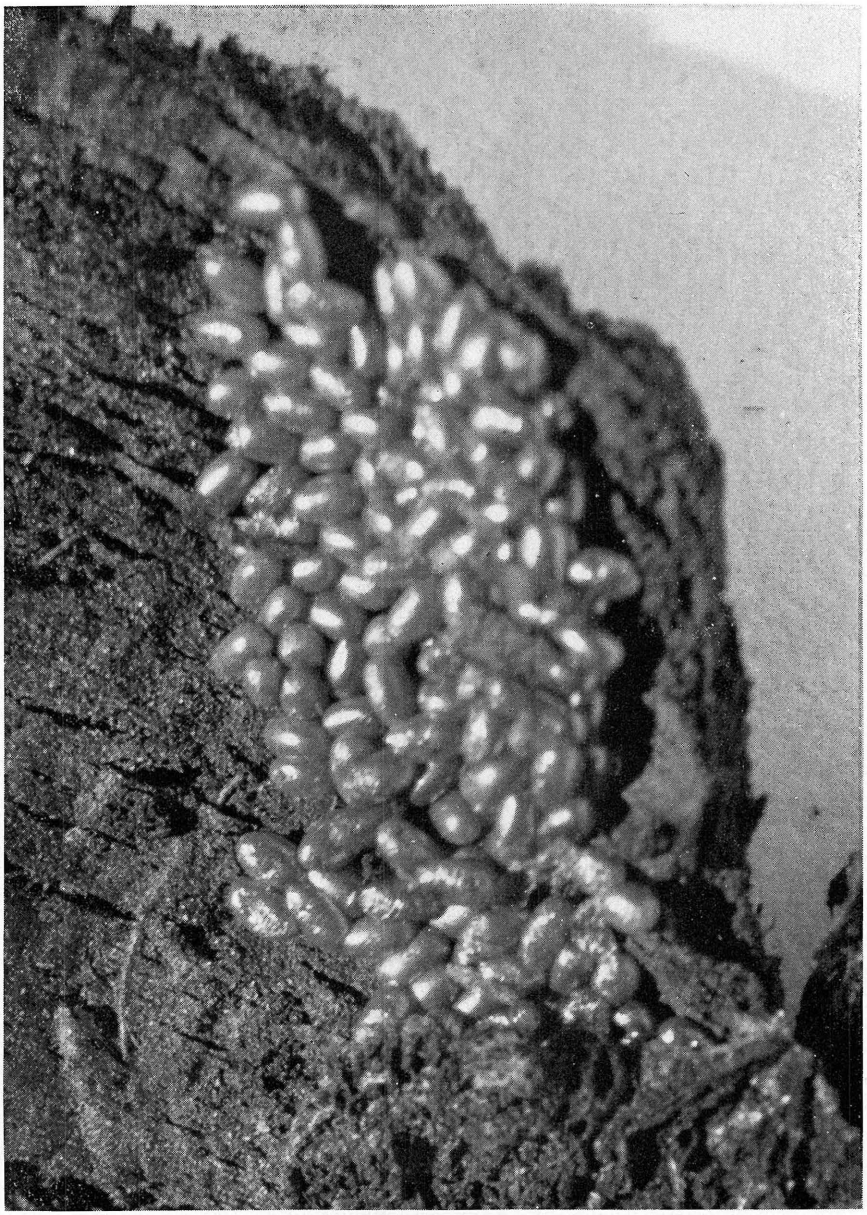


Fig. 30.—Egg mass of the spring canker worm.

THE EASTERN TENT CATERPILLAR MALACOSOMA AMERICANUM (FABRICIUS)

This common species is well known because of the prominent tent that it builds in crotches of trees and branches. It is very common on neglected apple trees and on other hosts especially wild cherry. The overwintering eggs are deposited in masses which encircle twigs and small branches. (Fig. 31) These masses are brown in color and may contain as many as 350 eggs. They are deposited in July and early August and hatch the following spring about the time that apple buds are showing the first leaves. The larvae are gregarious and group themselves in crotches where they construct a tent which they enlarge as they feed and grow. (Fig. 32) The tent is used for protection against natural enemies and unfavorable weather conditions. Larvae leave

Fig. 31.—Egg mass of the eastern tent caterpillar on twig.

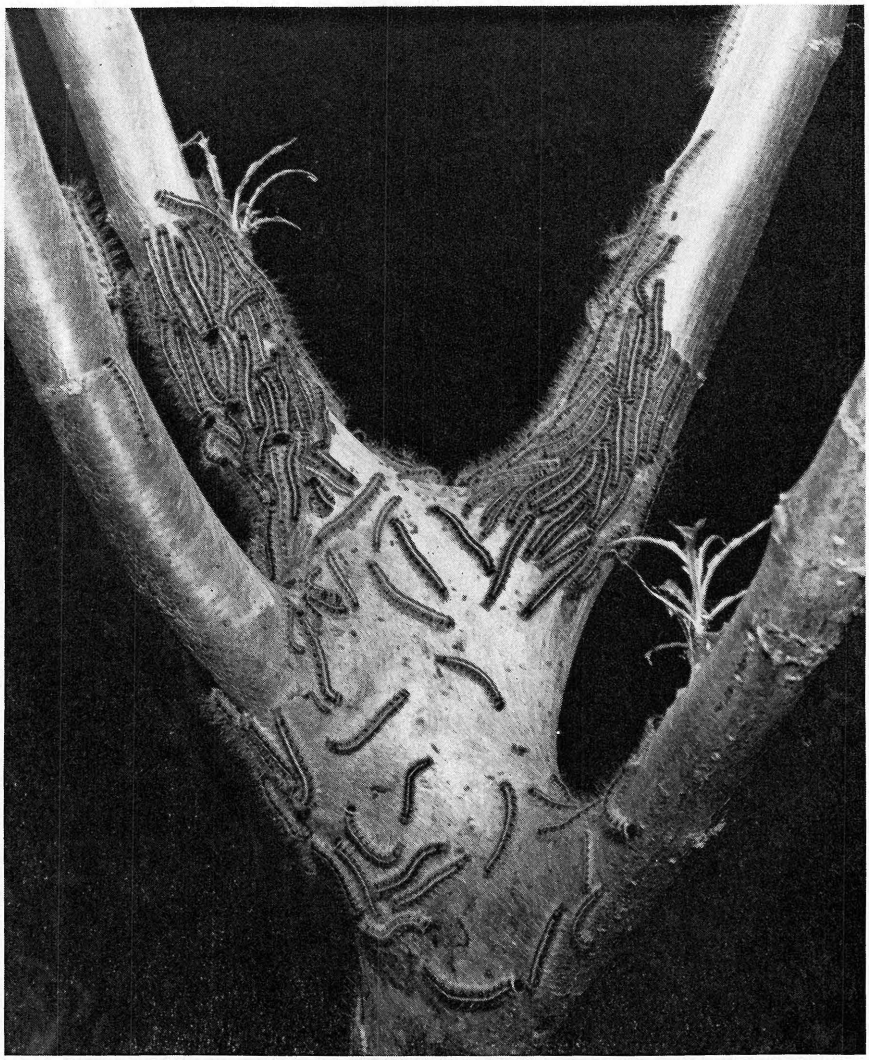


Fig. 32.—Larvae of the eastern tent caterpillar and small nest in the crotch of a young apple tree.

it only for feeding and finally when they are ready for cocooning and pupation. Mature larvae are about two inches in length, with a definite white stripe down the back and two white spots on each segment. Pupation occurs in a silk cocoon that may be found on the tree or adjacent objects. The moths are reddish-brown and have two white stripes on each forewing.

THE FOREST TENT CATERPILLAR MALACOSOMA DISSTRIA **HUBNER**

This caterpillar does not build a tent but constructs a web of silk on which the larvae gather after feeding or during moulting periods. The eggs overwinter in masses quite like those of the preceding species. In general, the life history of the two are quite similar. The mature larvae have one row of white keyhole-shaped spots down the back.

CLIMBING CUTWORMS EUXOA MESSORIA **(HARRIS) Plus Numerous Related Species**

Many different species of cutworm larvae will climb trees, bushes, and vines and feed on their buds. This work is done at night and during the day the "worms" hide in the soil and litter at the base of the tree. When buds are found destroyed wholly or in part and no insects can be found near, look around the base of the tree for the typical curled up cutworm larvae. In Ohio, grapes and at times peaches are more frequently attacked than apple especially in areas where orchards or vineyards have been established on sandy soil.

THE PISTOL CASEBEARER COLEOPHORA MALIVORELLA **RILEY**

This species is named from the grayish-brown, pistol-shaped case (Fig. 33) in which the larva lives during its feeding period. The

Fig. 33.—The pistol casebearer and injury to apple leaves.

parent is a small gray moth with fringed wings. The winter is passed by immature larvae in their cases which are attacked to branches. In the spring they attack buds and new leaves and in some cases do considerable damage especially to neglected trees.

When full grown the larvae and the case are about three-eighths of an inch in length. When mature they leave the foliage and again attach the case to twigs where pupation occurs. The moths emerge in late June and in July and eggs are deposited on the under surface of the leaf. When the larva hatches it bores through the leaf emerging on the upper surface with a tiny case already formed. Feeding occurs in July and August before the larvae start hibernation. The injury consists of numerous small holes in the leaf.

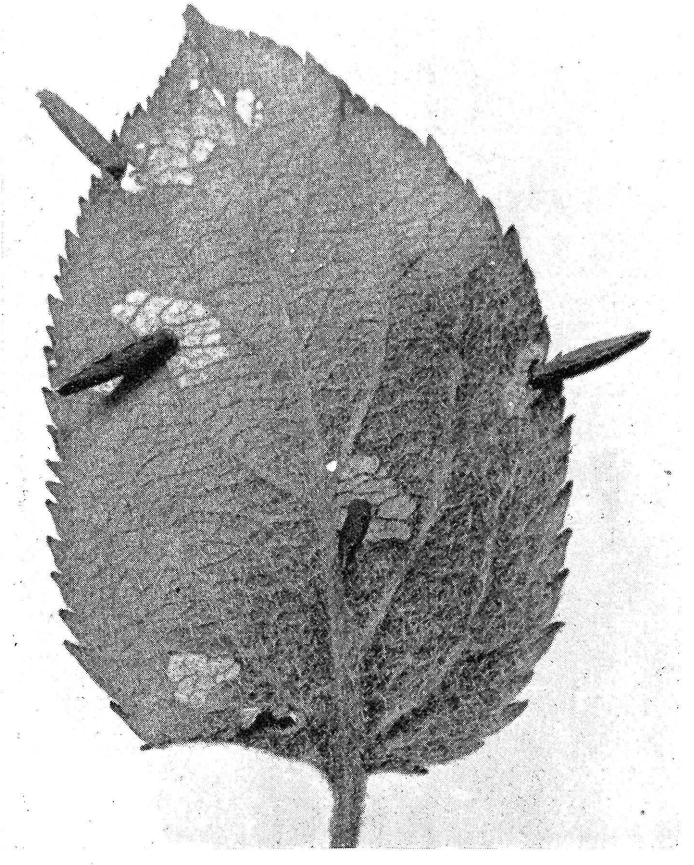


Fig. 34.—The cigar casebearer and injury to apple leaf. (Courtesy Dept. of Public Relations, Ontario Agricultural College, Guelph, Ontario).

THE CIGAR CASEBEARER COLEOPHORA OCCIDENTIS **ZELLER**

The larvae of this species live within a cigar-shaped case about the same size as that of the pistol casebearer. (Fig. 34) Otherwise the life history, habits and injury are much the same.

THE PEAR SLUG CALIROA CERASI **(LINNAEUS)**

The small, blackish-green, slug-like larvae are most commonly found on the leaves of pear, plum and cherry which they skeletonize. (Fig. 35) It also occurs on apple and other fruits. When mature the larvae may be up to one-half inch in length and are greenish-orange in color. They pupate in the soil and the adults emerge in late spring. These are sawflies which belong to the wasp and bee order. There are two generations per year.

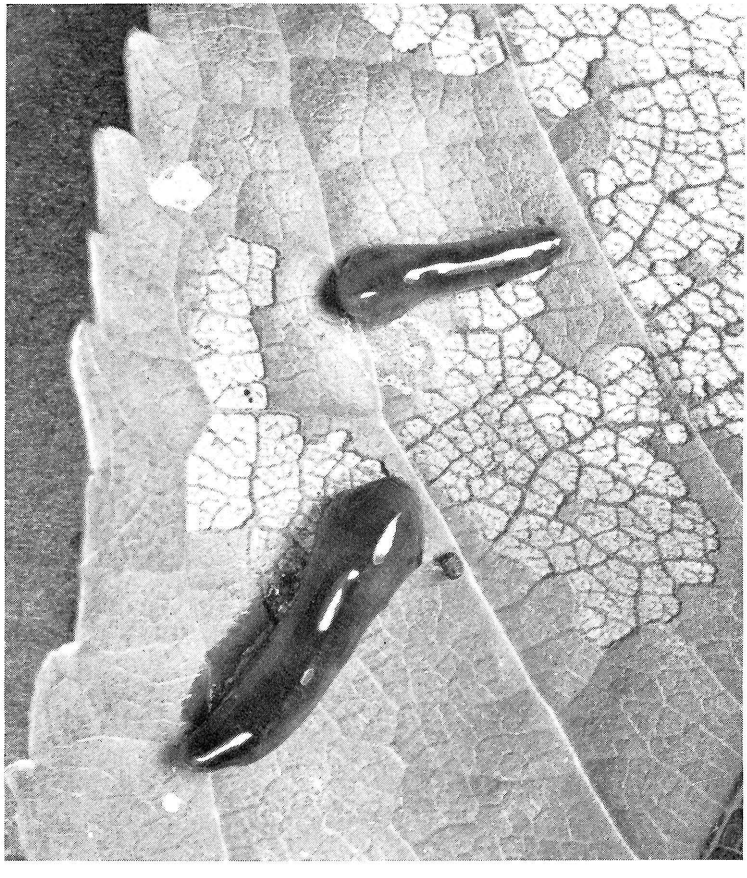


Fig. 35.—Pear slugs and injury on apple leaf.

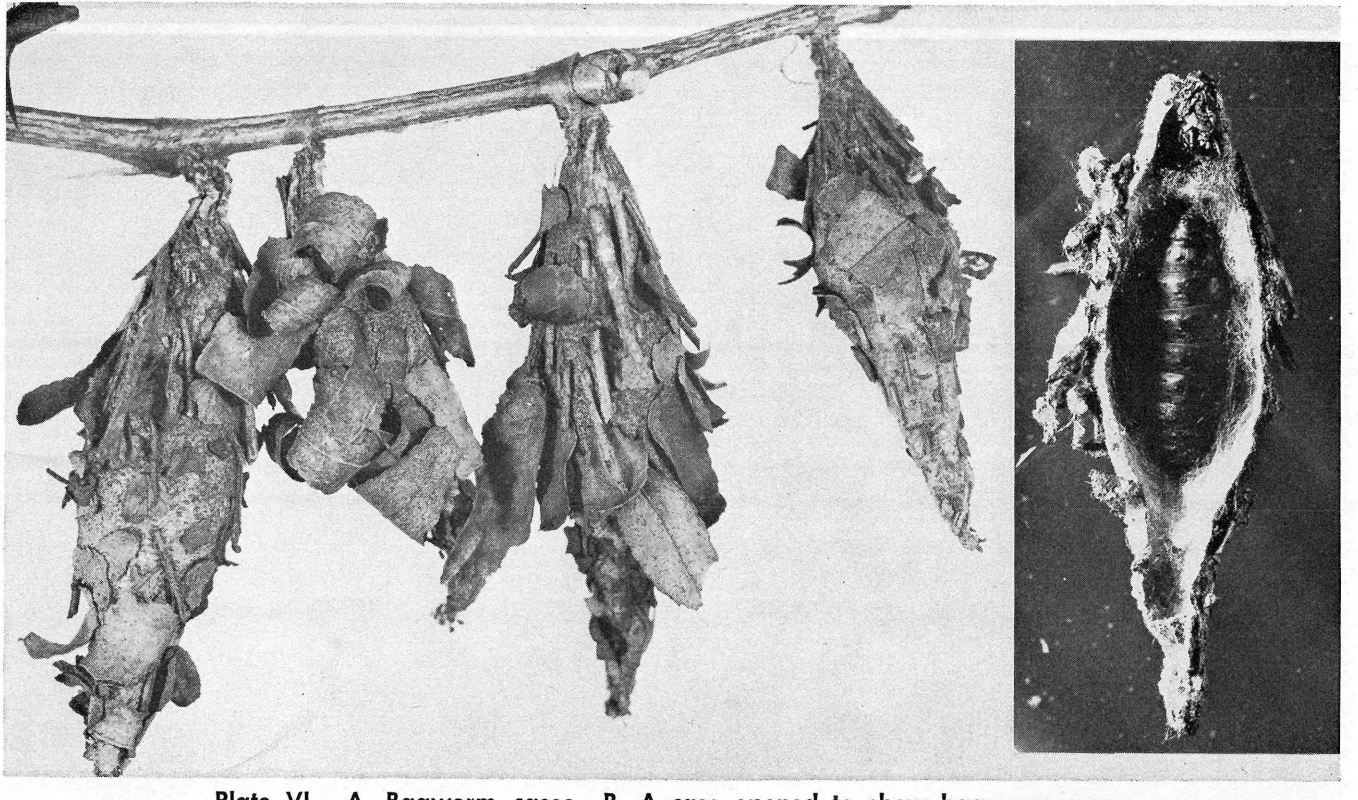


Plate VI.—A. Bagworm cases. B. A case opened to show bagworm pupa.

THE BAG WORM THYRIDOPTERYX EPHEMERAEFORMIS **(HAWORTH)**

This interesting insect occasionally attacks apple and other fruit trees but is more commonly found on arbor vitae and juniper. Soon after hatching in June the young larvae construct a bag of the material on which they are feeding, tying it together with silk. (Plate VI, Fig. A) In this the female spends her entire life, larval, pupal and adult, and finally ends it with the deposition of the eggs in the old pupa case. After pupation the male adults leave the bag and fly to the females which are fertilized through an opening at the bottom of the bag. There is only one generation per year, with the larvae feeding most of the summer and the winter being passed as eggs.

THE YELLOW-NECKED CATERPILLAR DATANA_MINISTRA **(DRURY)**

This large caterpillar is quite common on poorly or unsprayed apple trees in Ohio. There are also a large number of other hosts. Damage is caused by the caterpillars devouring the leaves (Fig. 37) leaving only a section of the midrib. Pupae live over winter in the soil and moths emerge and lay eggs in June and July. Caterpillars are common during July and August after which they enter the soil for the winter. When disturbed the caterpillars elevate both head and tail and will remain in this position for some time. They are yellow and black striped and have a spot or collar of bright yellow just back of the head. (Fig. 36)

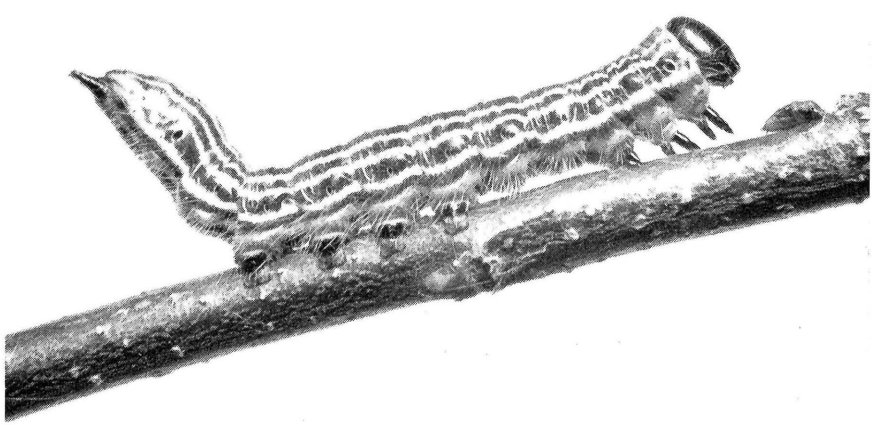


Fig. 36.—The yellow necked caterpillar.

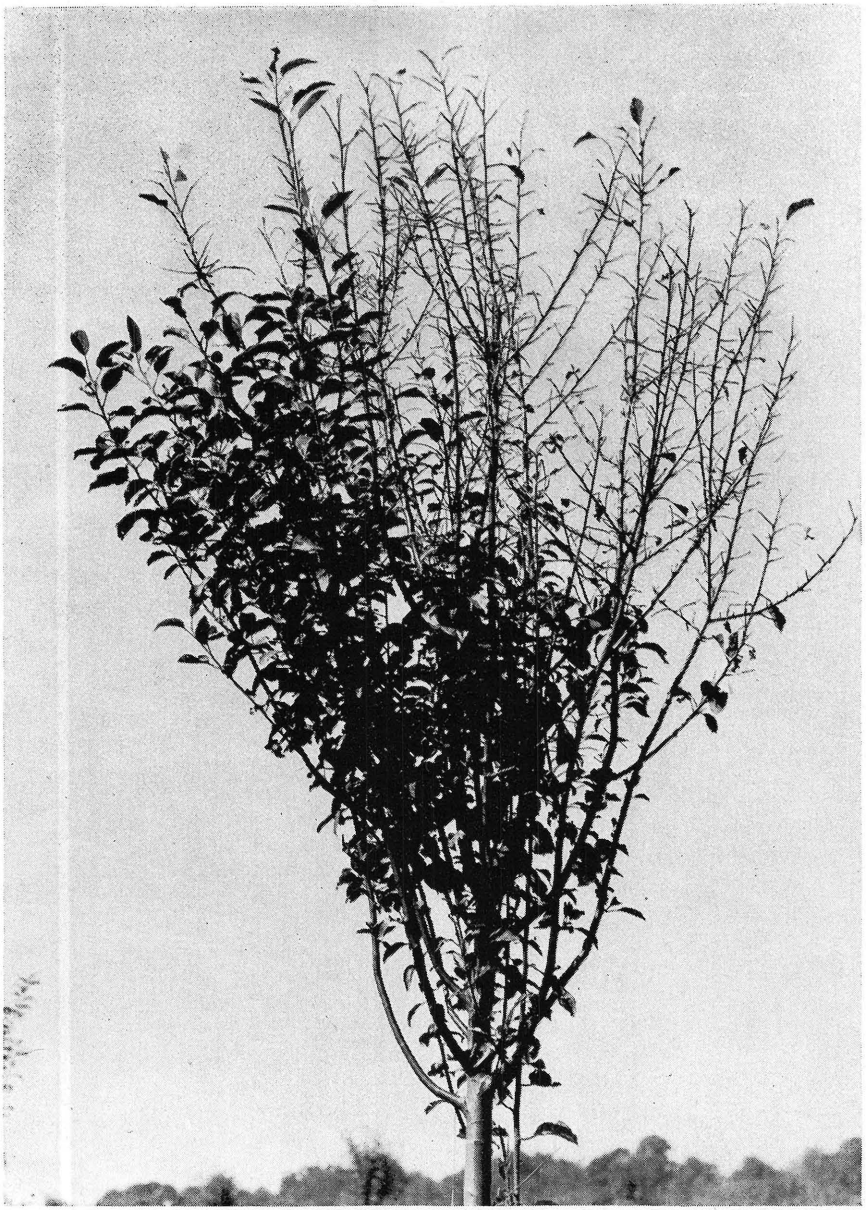


Fig. 37.—Apple tree defoliated by the yellow necked caterpillar.

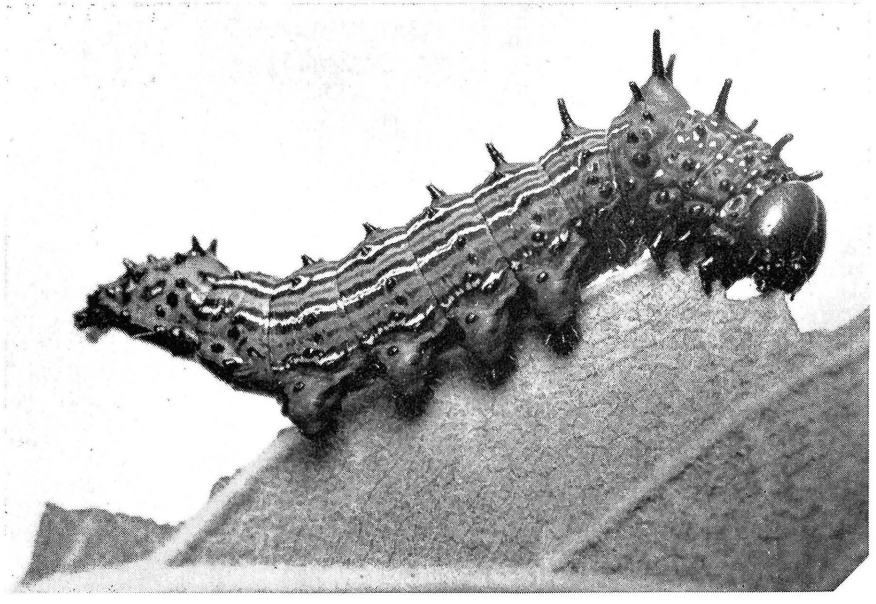


Fig. 38.—The red-humped caterpillar.

THE RED-HUMPED CATERPILLAR SCHIZURA CONCINNA **(J. E. SMITH)**

A raised, bright red spot on the first abdominal segment is characteristic of this species. (Fig. 38) The head is red and the body is marked with black and yellow lines. They are gregarious and often will defoliate single or adjacent branches. They are not quite as large as the yellownecked species but resemble them in their general feeding habits and life history. In southern Ohio there may be two generations per year.

THE FALL WEBWORM HYPHANTRIA CUNEA **(DRURY)**

In August and September, branches of apple and other trees are frequently seen covered by a loose, white web inside of which caterpillars are feeding. (Plate VII, Fig. A) These larvae are tan to brown in color and are very hairy. (Plate VII, Fig. B) They finally grow to a length of about one inch. The species overwinter as pupae in silken cocoons among debris on the ground. From these a pure-white moth emerges which has a wing span of about one and one-fourth inches. These adults lay masses of eggs which may include as many as 500 eggs per mass on the underside of the leaves during June. Two broods occur in some sections and in some seasons, but the work of the insect in Ohio is far more obvious during the late summer.

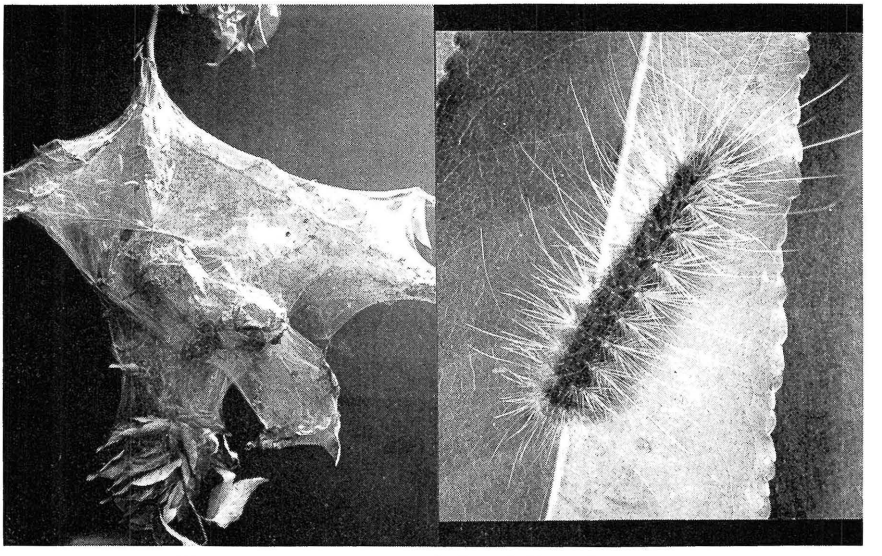


Plate VII.—A. Nest of the fall webworm
B. The fall webworm

LEAF MINERS

Several different species such as the unspotted leaf miner, *Callisto geminatella* (Pack), the apple leaf trumpet miner, *Tiocheria malifoliella* Clemens, and the locust leaf miner, *Xenochalepus dorsalis* (Thunberg), have been found attacking apple foliage in Ohio. The eggs of the different species are deposited on, or inserted into, the leaf. When

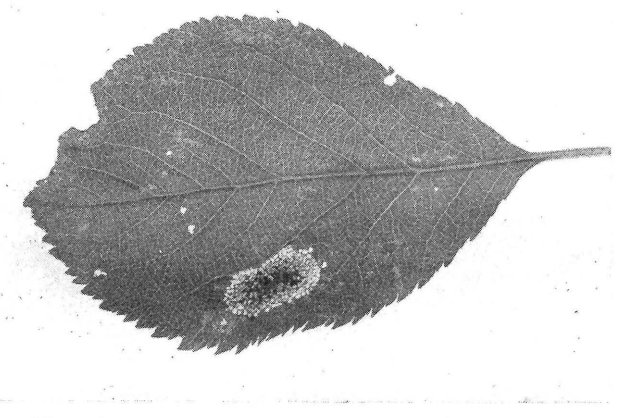


Fig. 39.—Injury by the unspotted tentiform leaf miner.

these hatch the young larvae feed inside the cuticle of the leaf thus creating a mine which may be thread like, trumpet like or of irregular shape. (Fig. 39) Usually these attacks are sporadic and have little commercial significance. However, on a few occasions considerable injury has occurred and control measures have been necessary.

THE APPLE FLEA WEEVIL RHYNCHAENUS PALLICORNIS (SAY)

This pest is a native insect and is found most commonly east of the Mississippi and north of the Ohio River. It also occurs in New York, New England and Canada. The small, black beetle (Fig. 40) is hardly one-tenth inch in length and is present in the orchard only in early spring after leaving hibernation and in early and mid-summer. The eggs are laid in small punctures along the midrib of the leaf in early spring. The larvae that hatch from these eggs mine the foliage and eventually form a blotch mine on the outer edge or tip of the leaf. In this they pupate and the adults emerge during late June and early July. They feed on the foliage for about one month after which they enter hibernation in thick sod and under debris. The injured leaves look very much as though a charge of very fine shot had been fired through them. Since the introduction of DDT and the organophosphates this pest has been of little importance in Ohio.

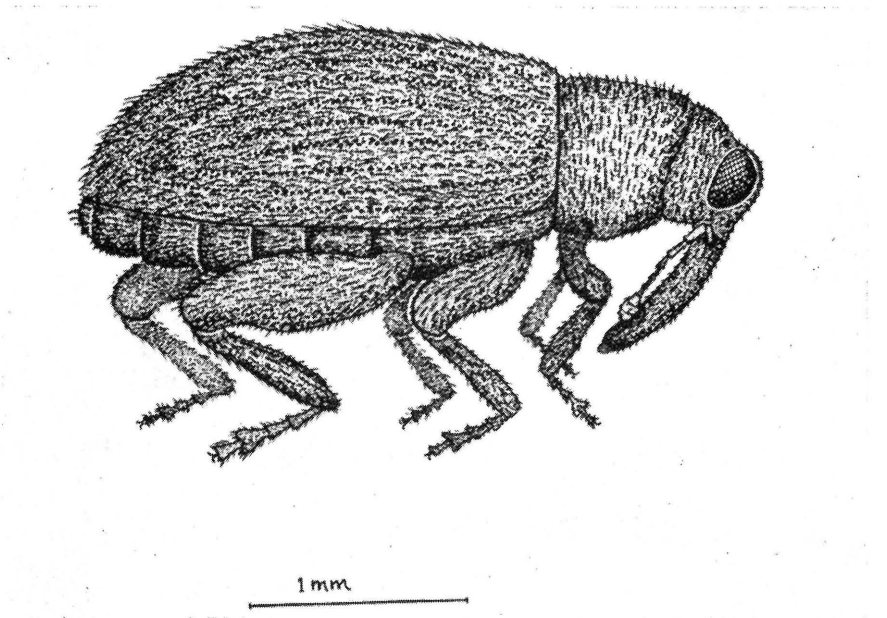


Fig. 40.—Adult of the apple flea weevil.

LEAF HOPPERS

These are a large group of sucking insects, of which many species attack apple. The young leafhopper or nymphs are small, wingless, and soft bodied and are usually found on the under surface of the leaves where they feed. They move rather rapidly sideways when disturbed but do not hop. The winged adults are found in the same locations. In the act of taking flight it makes a vigorous hop, hence the name of leaf hopper. In feeding, the leaf hoppers destroy cells and ingest chlorophyll which results in a grayish leaf that is unable to perform its proper function. Prior to the introduction of DDT leaf hoppers were a serious pest of Ohio apples. At present they do little damage especially in orchards where DDT is used, even in a few sprays. Some species, especially those feeding on grape, have become resistant to DDT, but as yet (1961) this is not serious in Ohio.

WHITE APPLE LEAF HOPPER TYPHLOCYBA POMARIA **McATEE**

This is the most common species in Ohio. Overwintering eggs are placed in slits in the bark of twigs and small branches. The eggs start hatching about the time that the first apple blossoms appear. The nymphs pass through five instars and the adults appear in June. Eggs deposited in June and early July result in a second generation of adults in August and September.

ROSE LEAF HOPPER EDWARDSIANA ROSAE **(LINNAEUS)**

One of the most widely distributed species in the United States is the rose leaf hopper. It closely resembles the white apple leaf hopper in appearance, life history and habits. However, it is not nearly as abundant in Ohio as *pomaria.*

THE POTATO LEAF HOPPER EMPOASCA FABAE **(HARRIS)**

This is a small green species that is a general feeder. It is especially serious on potato but may also cause damage to apple. It has one or two more generations per year than the other species.

APPLE LEAF HOPPER EMPOASCA MALIGNA **(WALSH)**

Another green species but larger in size than those already described. The eggs overwinter and there is only one generation per year. The injury is a characteristic cupping of the leaves on lush growing shoots or terminals. Injured leaves are frequently edged with yellow or brown. As the adults are most prevalent in June, injury is frequently noted only on leaves in the midsection of the growth. The species may be a severe pest on nursery stock.

Several different species belonging to the genus *Erythroneura* are also found on apple. These overwinter as adults and may frequently be observed in early spring after they have left their hibernating quarters. Most of these species have fairly conspicuous red markings either in lines or spots.

INSECTS ATTACKING TWIGS AND SMALL BRANCHES

SCALES

Scale insects are world wide in their distribution and there are hundreds of species. All scales secure their food by sucking the sap or plant juices of the host. They vary greatly in size, shape, habits, and life history. Some species are able to move about and change their place of feeding, while others must remain in the same place for their entire lives. In some cases the outer skin hardens and forms a protective covering for the body, while in others body exudates form a separate scale covering. These latter are usually called armored scales and it is in this group that the most severe scale pests of apple and pear are found.

In nature, scale insects are attacked and usually kept within bounds by small parasitic insects and also by various predators among which are found several ladybird beetles. Unfortunately these natural enemies are not always present to meet the needs of commercial fruit growers and chemical controls must frequently be used against the scales.

THE SAN JOSE SCALE ASPIDIOTUS PERNICIOSUS **COMSTOCK**

Specimens of this insect, or of its work may be found in most Ohio orchards. It is not abundant and current spray programs usually keep it at a level where it is not commercially damaging. However, it should be kept under constant observation and if increases are noted specific control measures should be applied. This scale is of oriental origin and was first found in the United States near San Jose, Califor-

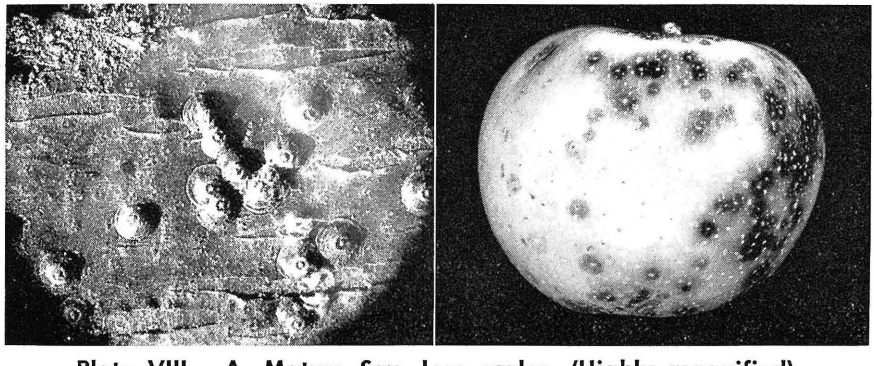


Plate VIII.—A. Mature San Jose scales. (Highly magnified)
B. Injury by San Jose scale to apple.

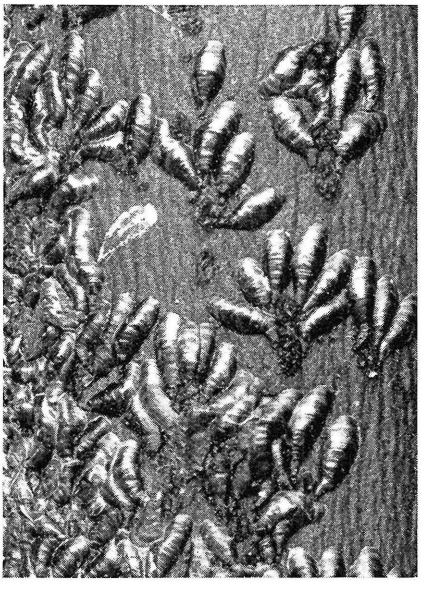


Fig. 41.—Oystershell scales on bark of apple.

nia. The first records of its presence in Ohio are dated in 1897 and from that time to about 1905, when effective controls were established, it caused tremendous damage to apple, peach, and other trees and shrubs. Adult female scales are about one-twenty-fifth of an inch in diameter or about pin head size. They are dull ash to black in color with a raised nipple like center of dirty yellow cast. (Plate VIII, Fig. A) Young scales are simply smaller without the yellow center.

Life History: The winter is passed as half grown nymphs, each under the protection of its individual scale covering. In the spring, growth is resumed and both males and females mature usually from mid-May to mid-June. The males are winged and move about fertilizing the females which remain under their scales. Soon thereafter, living young are produced which are called crawlers. These move about for a few hours then settle down and start feeding. When the first moult occurs, the cast skin together with other body excretions forms a scale covering over the young insect which has now lost its legs and has become little more than a sack with sucking mouth parts. Growth is rapid and under Ohio conditions there are at least two generations per year. As several hundred young may be produced by one female the possibilities of greatly increased populations and damage in a single season are easily seen.

Forbes scale and Putnam scale may at times be found on Ohio apple trees. They closely resemble San Jose scale and should be referred to entomolgists for positive identification.

THE OYSTER SHELL SCALE LEPIDOSAPHES ULMI **(LINNAEUS)**

This scale is so named because of its shape which resembles that of an oyster shell. It is of world-wide distribution and attacks apple, pear and other fruit, forest, and ornamental trees and shrubs. Lilac is a favorite host as are ash and willow. Heavy infestations result in the killing of branches and on occasion even entire bushes or trees. In the orchard this pest is usually kept under control by general spray programs and especially so by the sprays which are effective against the San Jose scale.

The scale which protects the mature female is about one-eighth inch in length, is restricted at one end and broader and rounded at the other (Fig. 41). The males have an oval and somewhat smaller covering. The cover is usually dark gray or brownish gray. They are most commonly found in masses, encrusting twigs or small branches.

Life History: The winter is passed as small, pearly-white eggs under the scale of the female. In late spring the eggs hatch and the crawlers move to new positions on the bark where they start feeding within a few hours. When the first moult occurs, the cast skin with other body exuadates forms the first scale covering which is enlarged as feeding and growth continues. The scales become mature in late August, at which time winged males emerge and fertilize the females. Oviposition then occurs after which the female dies. Her shriveled body is found under the anterior end of the scale. In Ohio there is only one generation per year.

THE SCURFY SCALE CHIONASPIS FURFURA **(FITCH)**

This fairly conspicuous white scale is a native of North America and is found in Southern Canada and in the United States (Plate IX). In common with the oyster shell scale it attacks many different fruit and forest trees. However, it is rarely a serious pest and in forty years of observation in Ohio the writer has seen only one serious outbreak. The anterior, narrow tip, of the scale is brownish, the remainder of the body white or light gray. The female scale is pear shaped and may measure up to one-tenth inch in length. The male is also white, much smaller, and has three dorsal ridges running lengthwise of its narrow body.

The life history follows almost the same pattern as that of the oyster shell scale. There is one generation each year in Ohio, though in the southern states two generations may occur. The eggs are purple-red in color.

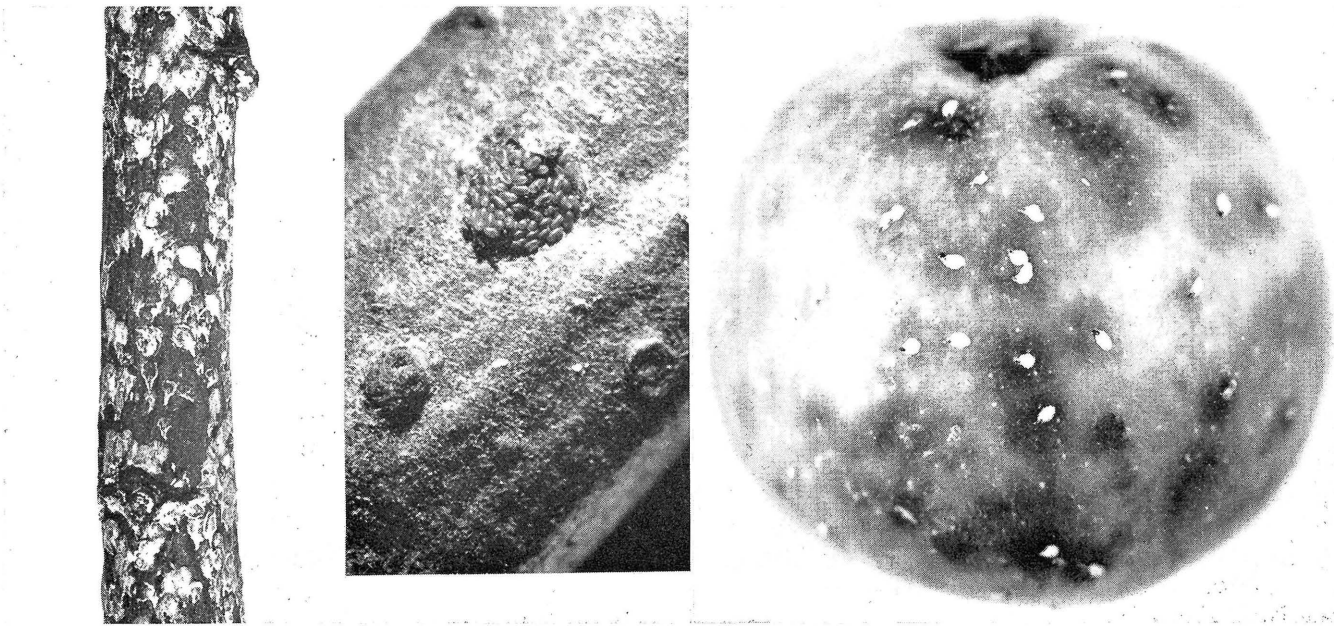


Plate IX.—A. Scurfy scale on apple twig. B. Eggs of the scurfy scale with scale cover removed.
C. Apple infested by scurfy scale.

Plate X.—A. Adult periodical cicadas on apple branch.
B. Young apple tree showing broken branches and twigs after cicada attack.

THE PERIODICAL CICADA (THE 17 YEAR LOCUST)
MAGICICADA SEPTENDECIM **(LINNAEUS)**

Despite the fact that this creature appears only once in 17 years, it is one of our best known insects in Ohio. This is due to the long feeding period of the nymphs and the almost magical appearance of the adults in the seventeenth and concluding year of their lives.

The adult cicada is about 1½ inches or slightly more in length. (Plate X, Fig. A) It has reddish brown legs and the body is black. The eyes are bright red and the veins of the wings are orange. They do not feed and even though they are present in tremendous numbers feeding is not a danger to crops or animals. The females, however, may severely damage young trees and shrubs by their habit of making punctures in the twigs where they deposit their eggs. These punctures are made by the curved, sawlike blades of the ovipositor, located at the tip of the abdomen. In each puncture or pocket the female will lay more than 20 eggs, placing them in two rows. As many as 20 punctures may be made in a single twig. One female will lay 400 to 600 eggs.

A special feature in the life of the cicada is its singing or drumming. During the period when the adults are present there is an incessant droning roar caused by the mingling of thousands of individual cicada voices. Volume of sound is at times so great that normal conversation is almost impossible. Only the males sing. They are equip-

ped with two membranous drums one on each side of the abdomen which vibrate and thus produce the "song."

The injury caused by the egg-laying habits of the females is especially damaging to young fruit trees which have been planted just prior to appearance of one of the cicada broods. (Plate X, Fig. B) Before 1948 no effective chemical control was known for this pest. During the attack in 1948 in eastern Ohio it was found that TEPP was fairly effective in killing the adults and later Sevin was shown to give excellent control. This now permits the planting of orchards just prior to

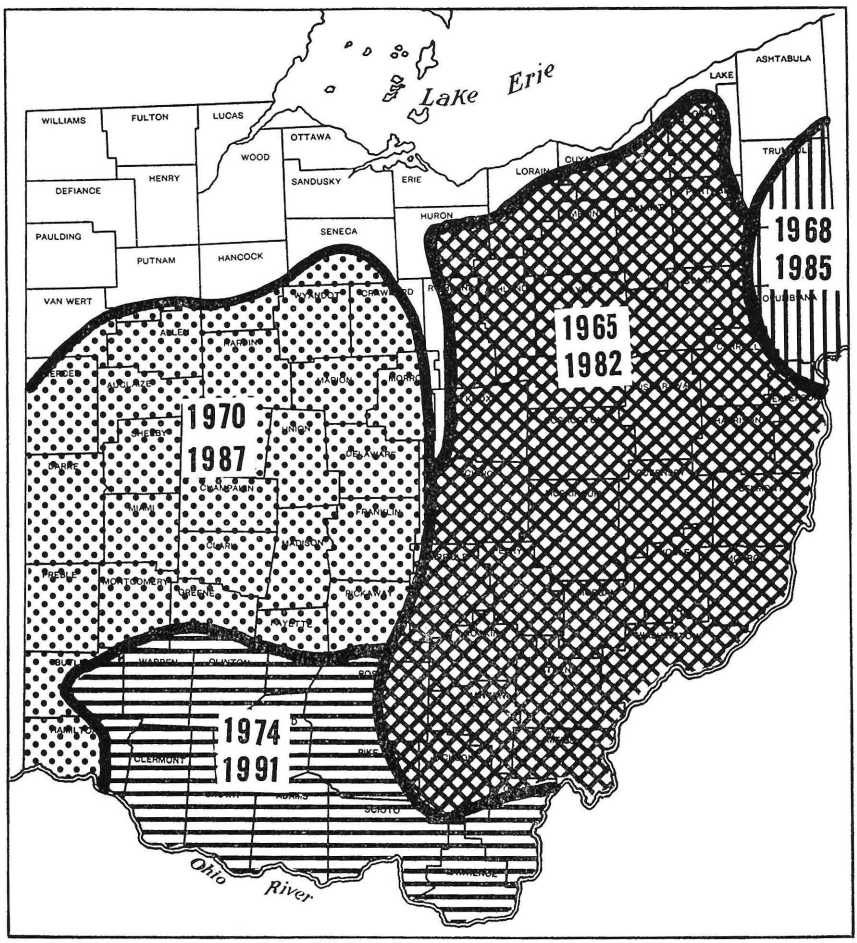


Fig. 42.—Map showing distribution of cicada broods in Ohio and years of appearance.

the year of appearance. Formerly the only reliable protection was to cover the young trees with cheese cloth or similar material.

The amount of injury to trees caused by the feeding of the nymphs on the roots is undetermined. However, it is logical to suppose that the effects of feeding by thousands of these immature cicadas might be serious. Apple decline may be due to such feeding.

In Ohio there are at least four distinct broods of the cicadas. Each requires the full 17 years for its development but they appear at different times. In the United States as a whole there are many more broods and in the south some broods require only 13 years for their growth. All of these broods have been plotted according to their geographic distribution and have been assigned numbers. Thus in Ohio we have Brood V whose next appearance will be in 1965, Brood VIII in 1968, Brood X 1970, etc. Their distribution in Ohio is shown on the map. (Fig. 42)

THE BUFFALO TREEHOPPER STICTOCEPHALA BUBALUS **(FABRICIUS)**

This is the most injurious of the different treehoppers that attack apples in Ohio. They do not injure the young trees by feeding but by the habit of depositing eggs in punctures made in the wood in much the same manner as that occasioned by the periodical cicada. Usually most of the eggs are deposited in wood of less than three-fourths inch diameter.

The buffalo treehopper, and other treehopper species as well, overwinter as eggs in the twigs of apple, or other hosts. In northern Ohio the eggs hatch in late May and the young nymphs fall to the ground where they feed on the stems of different plants. Legumes such as the sweet clovers and alfalfa are favorite hosts. Therefore, orchards planted in fields where legumes are common are most frequently injured by treehoppers. The nymphs feed from six to eight weeks and become adults in July and August. Egg laying soon follows. There is only one generation per year.

The adults of the buffalo treehopper are about three-eighths inch in length and are of a definite triangular shape with pointed structures above the head. These are supposed to resemble the horns of a buffalo, hence the name. The color is green.

Young trees may carry the parenthesis shaped scars on all parts of the trunk and branches and growth and vigor are definitely retarded. (Fig. 43) Injury may be greatly reduced by frequently mowing the orchard or by spraying the cover crop with a material such as parathion, applied about mid-June.

Fig. 43.—Injuries to peach twig from egg laying by buffalo treehopper.

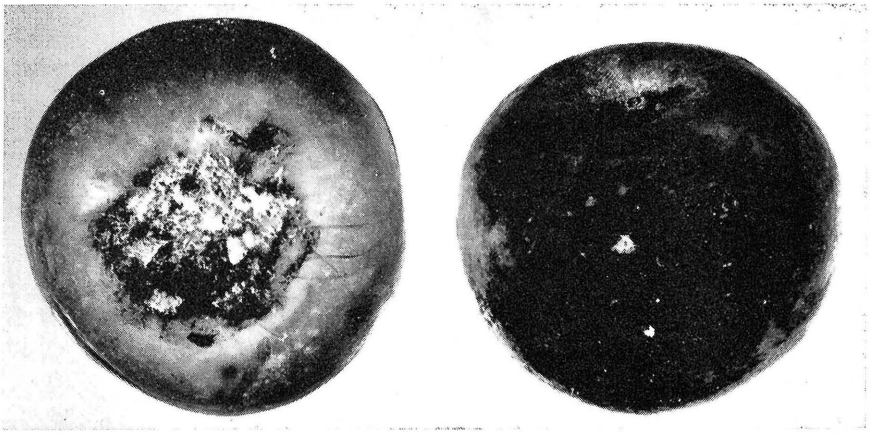


Fig. 44.—Apple on left has colony of Comstock's mealybug around stem, A sooty fungue is growing in the black areas. Apple on right shows heavy growth of the black fungus.

COMSTOCK'S MEALYBUG PSEUDOCOCCUS COMSTOCKI **(KUWANA)**

This insect came originally from Japan and has been present in Ohio for at least 40 years. It was first found attacking Umbrella catalpa and in 1939 it appeared on apple in serious numbers. Fortunately the infested orchards were limited to a small area in Lawrence County. None of the insecticides of that day gave control, but introduced parasites reduced the mealybug to harmless numbers by 1943. Since that date it has not been injurious.

The insect overwinters as eggs, protected in white woolly masses in crevices and under bark scales on the trunk and branches. Eggs hatch as buds are opening, and nymphs which are flat and covered with white powdery wax feed for about one month before becoming mature. Scar tissue, small twigs, water sprouts and at times the fruits are attacked. There are three generations a year. The principal injury to apple is caused by the dropping of honeydew on the fruit followed by the growth of a black fungus. (Fig. 44) This seriously discolors the fruit and is almost impossible to remove.

INSECTS ATTACKING THE TRUNK, LARGE BRANCHES AND ROOTS

BORERS

Insects whose larvae live by cutting or boring through living wood or bark are usually known as borers. Many of these larvae are the progeny of moths, but the species that are most harmful to apple belong to the beetle family.

THE FLATHEADED APPLE TREE BORER CHRYSOBOTHRIS FEMORATA **(OLIVIER)**

Trees that have been weakened by factors such as the shock of transplanting, drought, defoliation, root trouble, or other causes are frequently attacked by this pest. The borers particularly prefer to attack the side of the trunk or branches exposed to the sun. In addition to apple, many other fruit, shade and forest trees are attacked.

The overwintering form is the mature larva (Fig. 45) which hibernates in its burrow in the solid wood. Prior to pupation the larva cuts a channel directly to the outside bark surface which is used by the mature beetle in emerging. The adults appear usually during the month of June and mating and egg laying soon follow. Warm, sunny days speed up these functions. In depositing eggs the female runs rapidly up and down the trunk or branch that is exposed to the sun and when a crack or crevice in the bark is located one or more eggs are deposited in it. These eggs hatch and the larvae burrow through the bark. Finally they enter the wood where the burrows are extended and they overwinter. In Ohio the life cycle is usually completed in one year.

A prime factor in the control of the flat-headed borer is the maintenance of tree vigor.

Fig. 45.—Larva of the flatheaded apple tree borer. Injury is also shown.

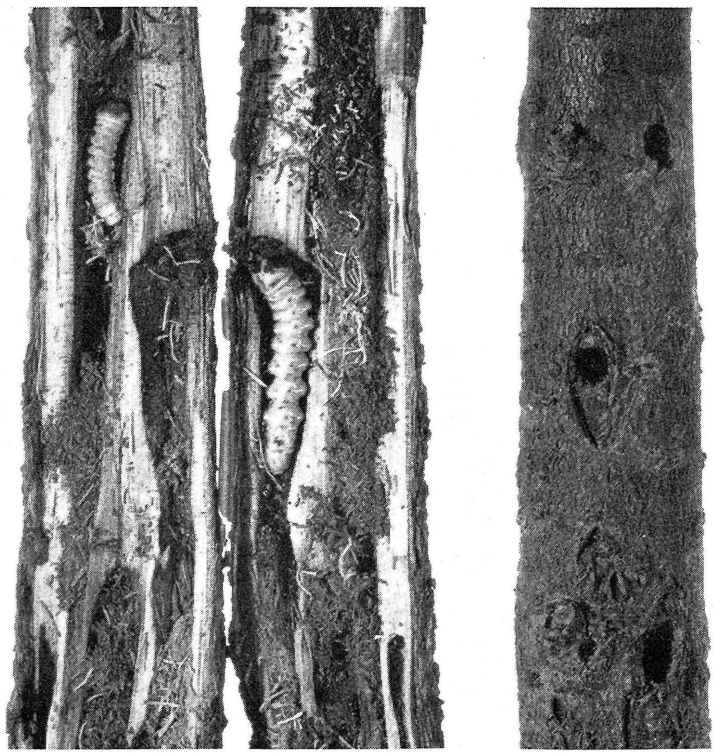


Fig. 46.—Work of the roundheaded appletree borer showing larvae in tunnels prior to emerging as adults. Sections at right shows exit holes of the adult beetle.

THE ROUNDHEADED APPLE TREE BORER SAPERDA CANDIDA **FABRICIUS**

In Ohio generally, this species is not a severe pest but in certain orchards it has done a great deal of damage. The eggs are laid at ground level in slits in the bark during June and July and the resulting larvae bore into the bark and wood at this point. This activity is manifest by exudations of reddish-brown frass or sawdust like material commonly found around the base of the tree. The larvae spend two or three years feeding in the wood and during this period the tree may be girdled, especially if several larvae are present. Burrows may also be made in the roots. During the last season of feeding a channel is made upward to a height of from three to eight inches above the soil level where it turns outward to just beneath the bark surface. The larva then returns to the main burrow where it spends the winter (Fig. 46). In late spring pupation occurs followed by emergence of the adult beetle through the exit channel (Fig. 47).

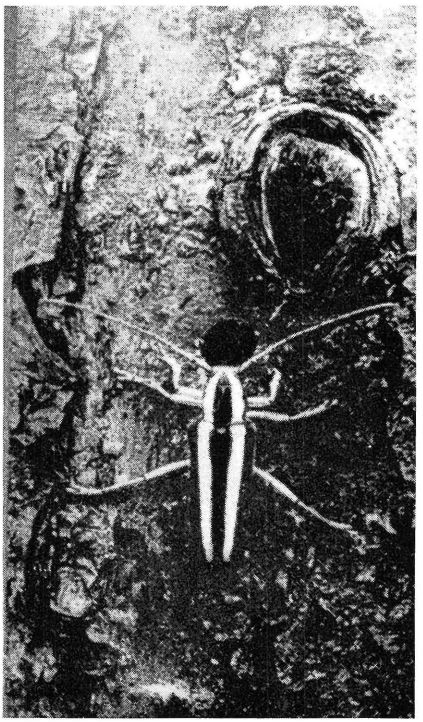


Fig. 47.—Roundheaded apple tree borer adult at exit hole from which it has just emerged. (Courtesy U. S. Dept. of Agriculture).

In addition to apple, favorite hosts are the service or shadbush, crab apples, mountain ash, and other fruit trees. Wild hosts may serve as a reservoir from which the beetles migrate to nearby orchards. Therefore, the eradication of the native hosts from areas close to apple plantings will aid greatly in control. Keeping the base of the tree covered with a paper wrapping from early June to September will prevent egg laying.

THE BROAD-NECKED ROOT BORER PRIONUS LATICOLLIS **(DRURY)**

This is one of the largest beetles found in Ohio. The larvae (Fig. 48) which when full grown are also exceptionally large, bore in the wood of apple and other fruit and forest trees. They may also attack grape and blackberries. One of these larva is able to completely cut off the trunk of a four or five year old apple tree. Fortunately, the insect is rather rare and damage is usually noted only in old orchard trees. Injury occurs at the base of the tree and in the larger roots.

If frass is noted about the base of a tree, the larvae may be cut out with a knife or chisel or the burrow probed with a wire to effect the destruction of the larvae.

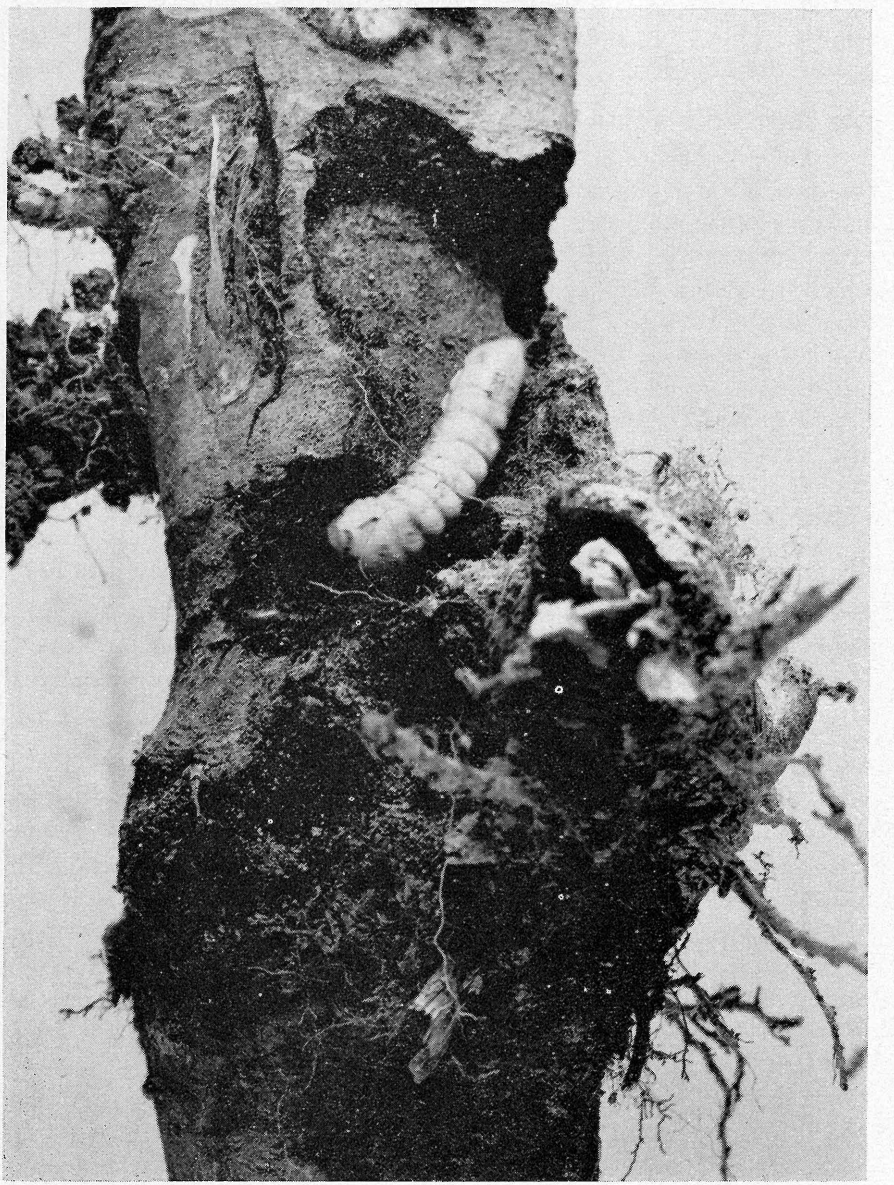


Fig. 48.—Larva of the broad-necked root borer and damage at base of young tree.

THE APPLE BARK BORER THAMNOSPHECIA PYRI **(HARRIS)**

The larvae of this species is occasionally found feeding in shallow, wet tunnels in the bark of the trunk and the larger branches of apple and pear. The parents of the larvae are small clear wing moths closely related to the lesser peach tree borer. Injury of economic importance is quite rare in Ohio.

THE SHOT-HOLE BORER SCOLYTUS RUGULOSUS **(RATZEBURG)**

These beetles came from Europe almost 100 years ago and are now common in most parts of the United States. They have a wide range of host plants including all the deciduous tree fruits. In spring or early summer the small, brownish-black beetles are attracted to trees which are dying or in a weakened condition. A small hole is chewed through the bark to the wood where a longitudinal tunnel is cut out. Along the edges of this tunnel eggs are laid. When these hatch, the larvae bore out smaller tunnels usually running at right angles to the parent gallery. These can circle the branch and the girdling action may cause its death. Dead bark peeled away from the branch will disclose the general pattern of the tunnels. The full grown larvae pupate and transform to adult beetles (Fig. 49) at the end of their particular gallery. The beetles then cut tunnels to the surface (Fig. 50) and a new generation is started. In Ohio there are two of these per year. Vigorous trees resist the attack of this borer very well and therefore good cultural methods are one of the best means for its control. Sanitary measures such as the prompt removal from the orchard of dead or dying wood are also recommended.

WOOLLY APPLE APHID ERIOSOMA LANIGERUM **(HAUSMANN)**

The woolly apple aphid is a species common and generally known throughout Ohio but of late years, at least, it has caused little concern to commercial growers. It is still a pest of considerable importance to nursery men engaged in propagating the apple. The species is best identified by the appearance of the colony which consists of a number of brownish to purple lice covered by an abundant, bluish-white, woolly excretion. The colony above ground is usually located at the base of a leaf petiole, or about wounds or pruning scars (Plate XI, Figs. A and B).

Life History: This insect passes the winter in two different forms; first, as eggs on elm trees, and second, as living individuals on the roots of apple and other closely related plants. In the spring the eggs hatch and the young aphids feed upon the elm leaves which they cause to curl into a rosette. In this rosette, winged aphids develop that fly to

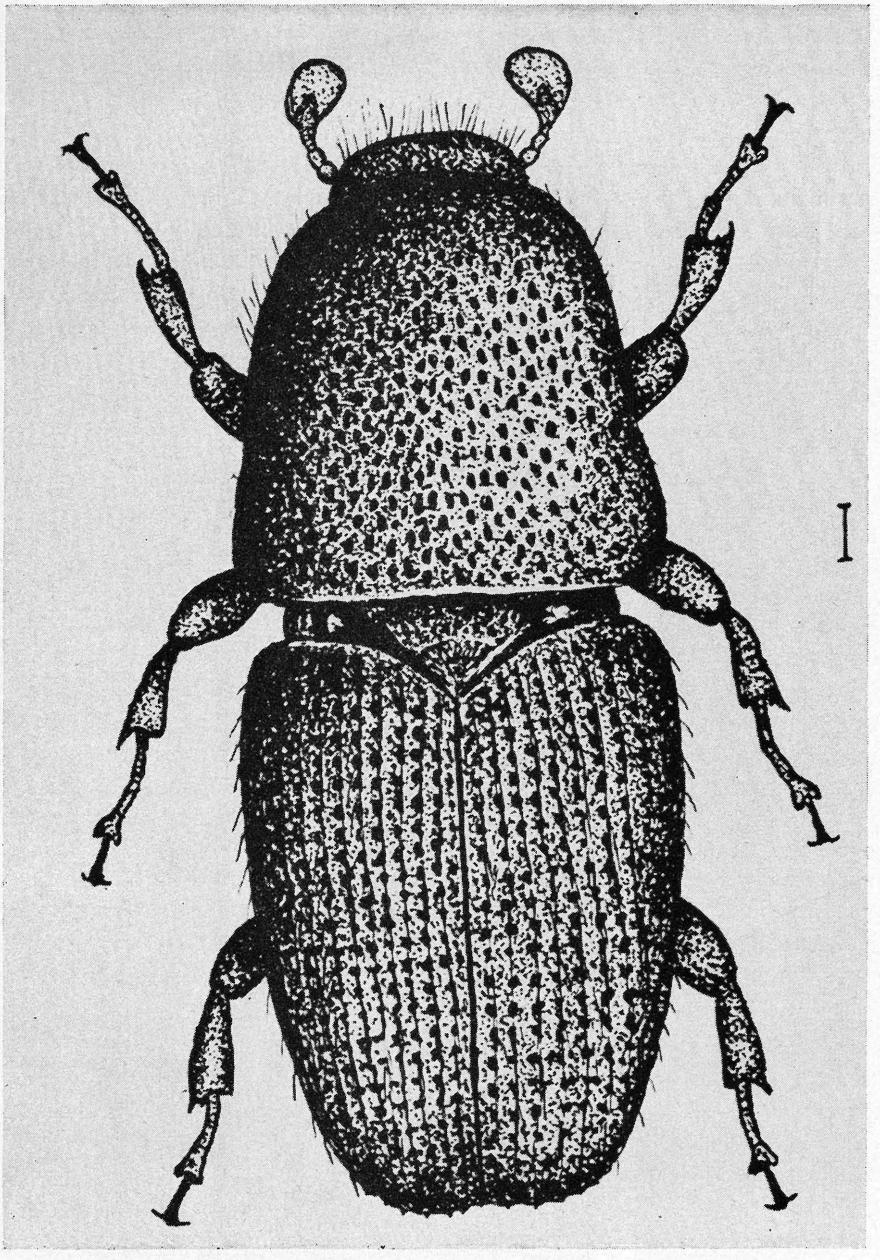


Fig. 49.—Scolytus rugulosus **(Ratz) a common shot-hole borer.**

apple; in northern Ohio this flight is usually noted during the first part of June. On apple, colonies are formed in the locations noted above and from these at different times during the summer certain individuals move to the roots. In autumn, winged forms appear in both the aerial and the root colonies and these return to elm where the sexual forms are produced and the eggs laid. Of the aphids that remain on apple, those in the aerial colonies are killed by winter weather, but those on the roots live and continue reproduction the following year. The injury done by these species consists of gall-like formations. (Plate XI, Fig. C) on the branches and of swollen enlargements on the roots. These are started and increase in size from year to year due to the feeding of the aphids. Such galls at times form a favorable place for the attacks of various fungi.

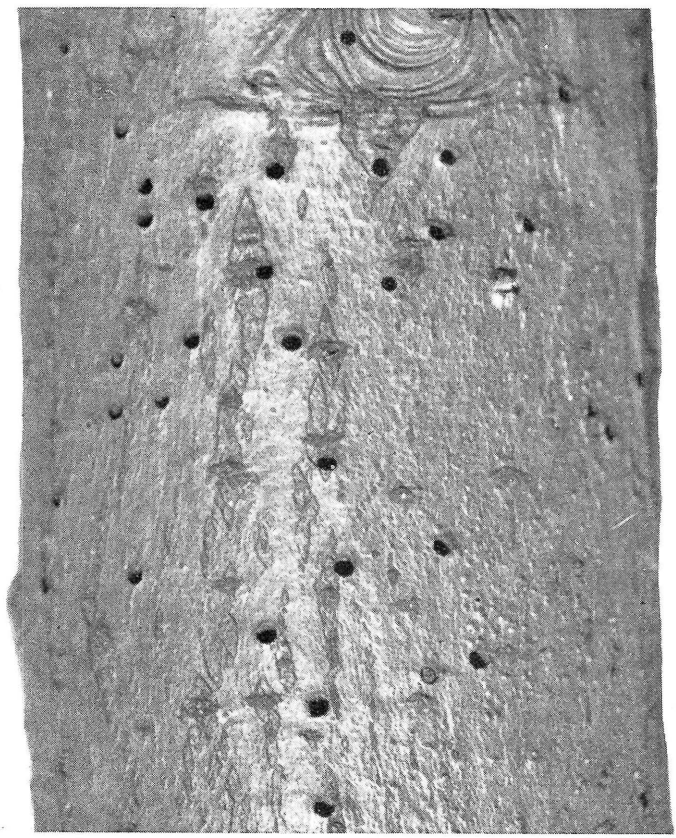


Fig. 50.—Apple branch showing exit holes of the shot-hole borer. (Courtesy of the U. S. Dept. of Agriculture).

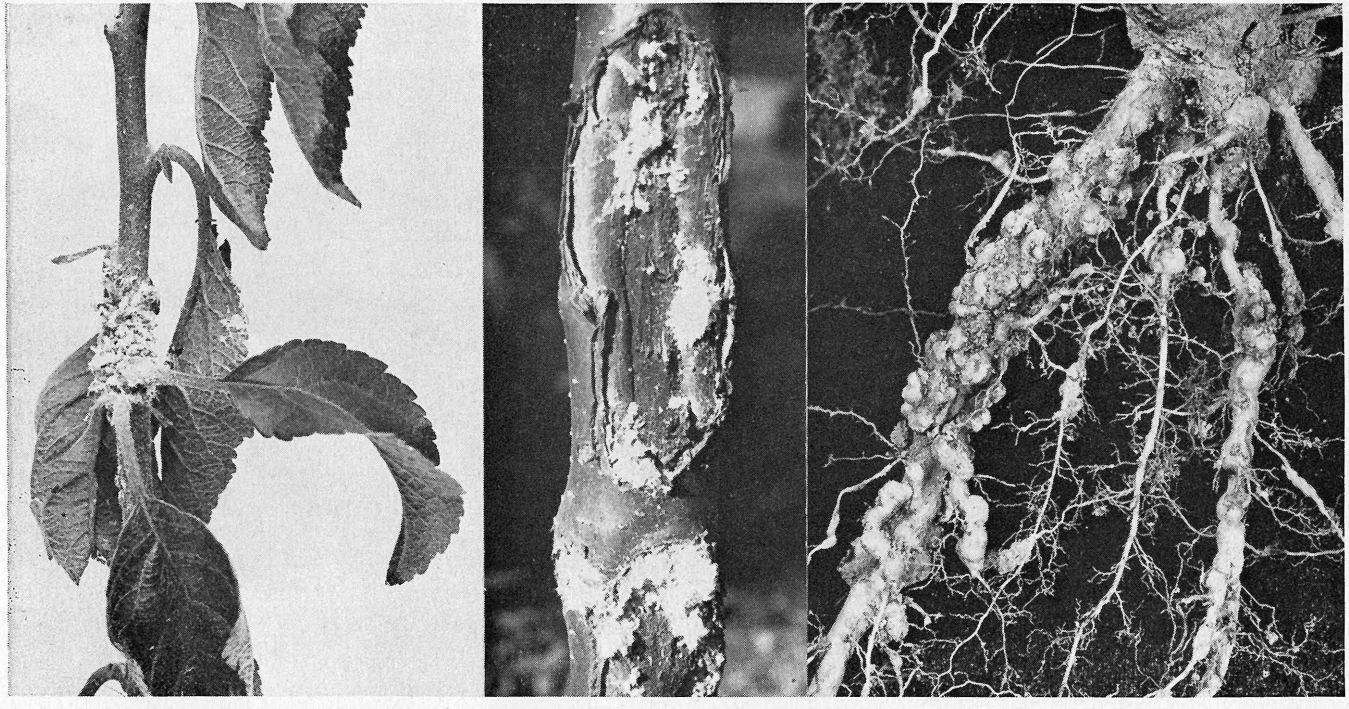


Plate XI.—A. Aerial colony of woolly apple aphid on water sprout.
B. Aerial colony of woolly apple aphid on scar tissue around old wound.
C. Typical nodules on apple root caused by the feeding of the woolly apple aphid.

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The author hopes that all who have contributed to this publication will recognize the part that all have played and accept his sincere thanks. Investigations reported in this publication have been in progress for almost one-half century and many who assisted and are no longer with us are gratefully remembered.

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